COLLEGE OF ENGINEERING CORNELL UNIVERSITY

the Cornell engineer

FEBRUARY, 1955

VOL. 20, NO. 5

25 CENTS

Sanford W. Wilson, class of '48
speaks from experience when he says . . .

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MR. WILSON was interviewed by U.S. Steel representatives in March of 1948. After receiving his B.S. in Chemical Engineering in June, he chose his U.S. Steel offer over several other job offers and began working at the huge Gary Works as a Foreman Relief Trainee. He gained experience in the Blast Furnace Department and in the front office learning the business end as well. In November of 1954 Mr. Wilson was made assistant to the superintendent of blast furnaces at Gary. His duties now include developing data for control of production, quality of materials, costs, and making technical reports. In addition, he directs the activities of Technological Co-Ordinators and part of the training of management trainees.

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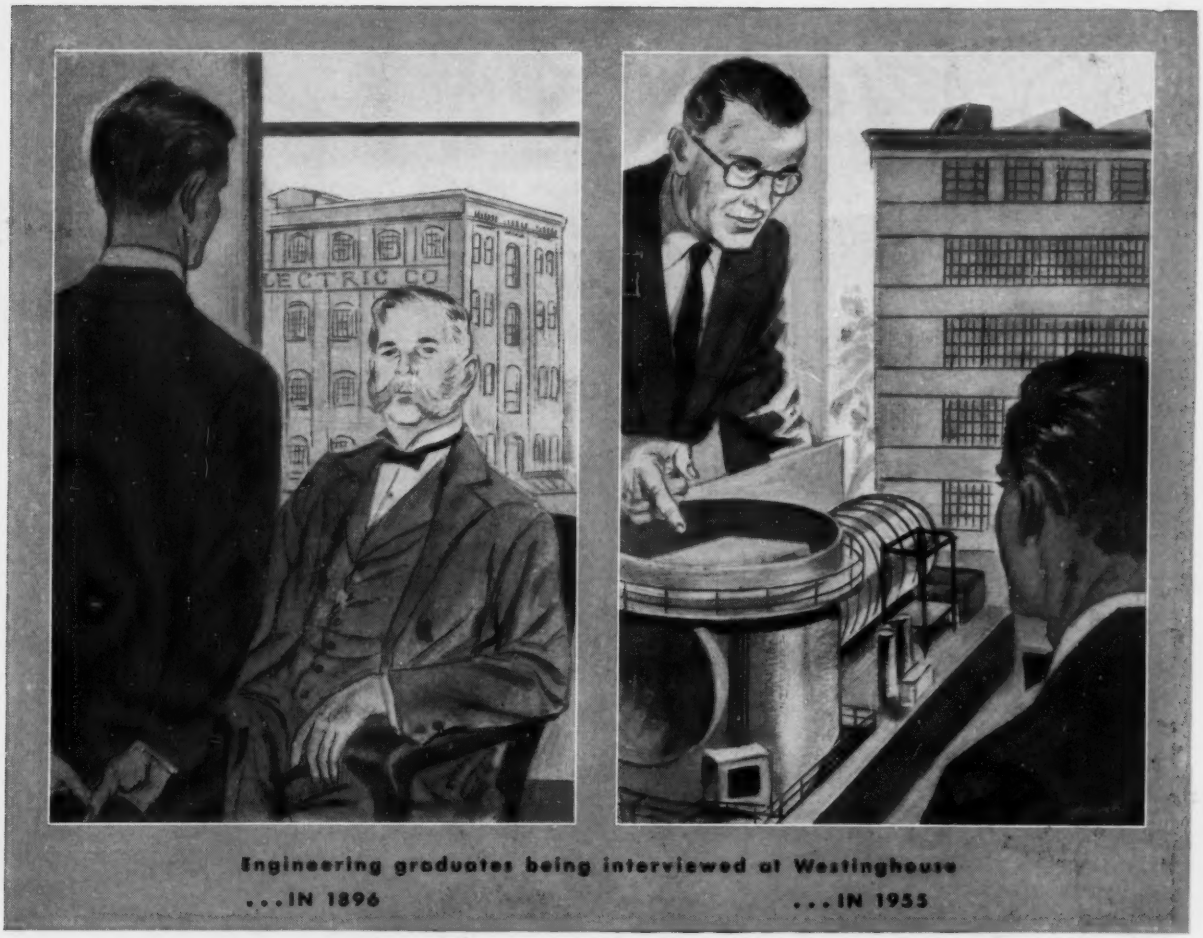

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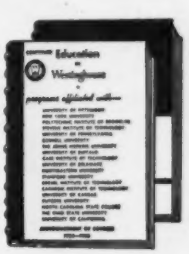

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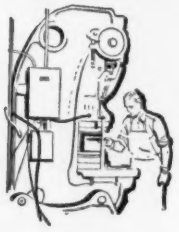

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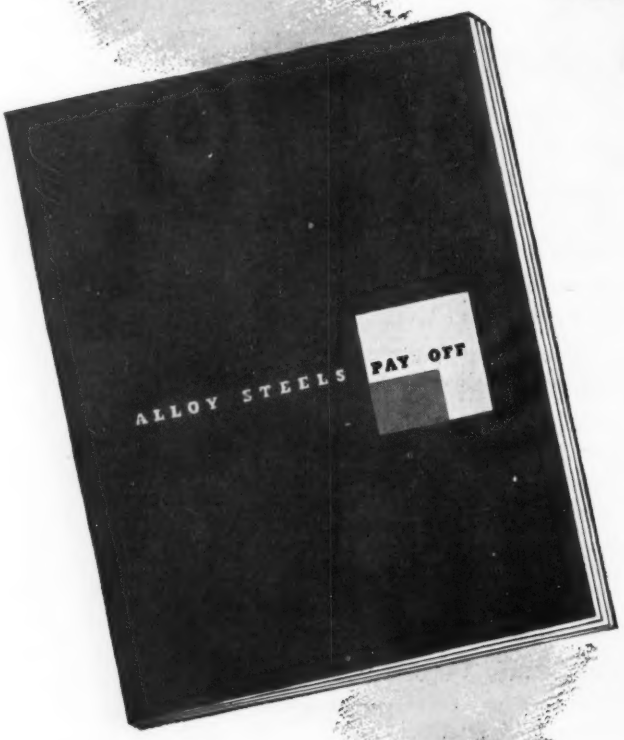

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Prevention of Corrosion To Reserve Ships

by OLIVER BRAGG, M.E. '50

Everyone thinks he knows what corrosion is, but only a comparatively few understand its importance to the Atlantic Reserve Fleet, and how "cathodic protection" can ward it off.

The Atlantic Reserve Fleet consists of tens of millions of square feet of exposed metal surface, molded into the form of hundreds of inactivated ships of all types, classes, and ages. These widely varying ships all have one common characteristic—they are corrodible. Although they are inactive, the fight against deterioration of the hull and exposed machinery never ceases; for these ships, together with the Pacific Reserve Fleet, are our naval insurance against another time of need which may call for expanded seapower. The very nature of this possibility demands that a high degree of preservation be maintained, but the premium for this protection is in tax dollars and men and materials which otherwise could be used for active fleet purposes. This is the major reason why the number one item stressed in the basic Reserve Fleet policy calls for "the administration of the Fleet with a view to the utmost economy in personnel, material and service, consistent with maintenance of the required degree of readiness."

Drydocking costs loom large in maintaining a fleet, whether it be active or inactive. These costs not only must include bottom repainting or re-preservation, but they also include such items as these: emergency dockings to correct leakage, renewing and testing the thickness of shell plating, welding pits, renewing zincs and many other items, necessary for the most part simply because anticorrosive paints and other corrosion-protection devices have failed.

This is the preservation problem that Marine and Corrosion Engineers have been working on ever since vessels first had metal bottoms. Before we can see how "cathodic protection" comes into the preservation picture so far as the Reserve Fleet is concerned, we must understand clearly what the corrosion problem actually is.

The Corrosion Problem

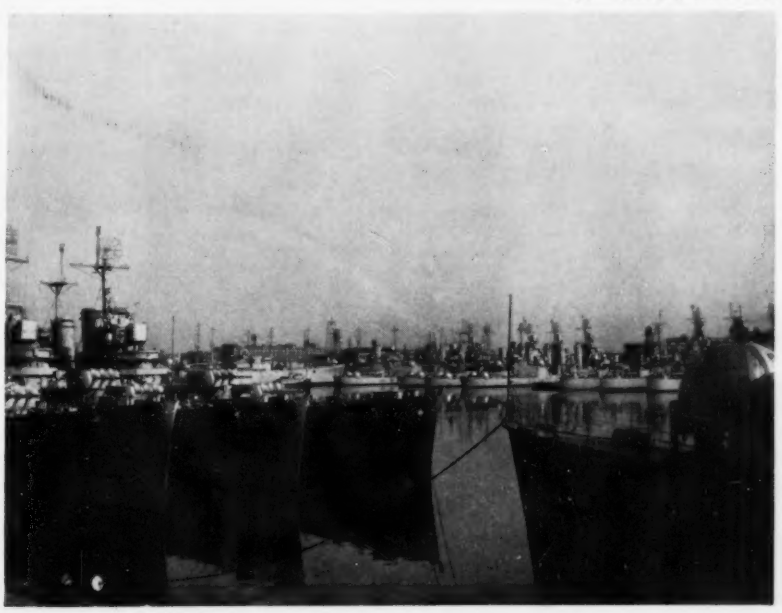
Any metallic surface in direct contact with an ionizable liquid, such as sea water, is subject to the phenomenon of galvanic corrosion. This results from the flow of electric current from high potential anodic areas to lower potential cathodic areas. Negatively charged metallic ions are formed at the anodic areas. This results in an equivalent loss of weight to the metal as the metallic ions combine with the ionized liquid to form rust and scale, while hydrogen is being liberated at the cathode. The loss of metal is apparent first by a roughened surface under the rust. After a period of time a distinct pitting effect can be observed. Finally, if this condition is allowed to continue, the metal itself fails.

This reaction is not new in our day. Galvani and Volta tested the principle and every school boy learns about it in his high school days when he studies the common dry cell. The chief difference now is that the elements of the "cells" are not as easily recognized. We pass from the familiar physical characteristics of dry cells and other bi-metallic couples immersed in an electrolyte, to a situation where the high and low potential areas may exist in one piece of metal. The electrolyte is now sea water and the return path for the electrical current is no longer an outside piece of wire, but is the metal itself.

This further bit of explanation should make the action clear. We

Part of the Atlantic Reserve Fleet in anchor at Philadelphia.

—official photograph, U.S. Navy



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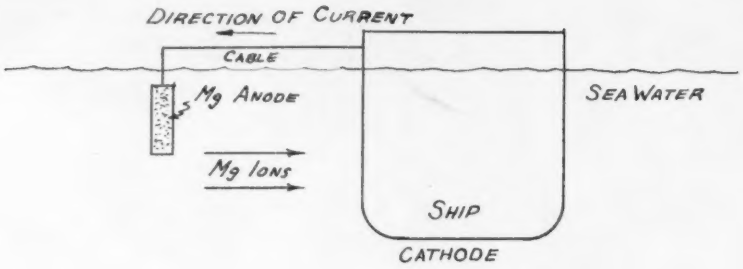
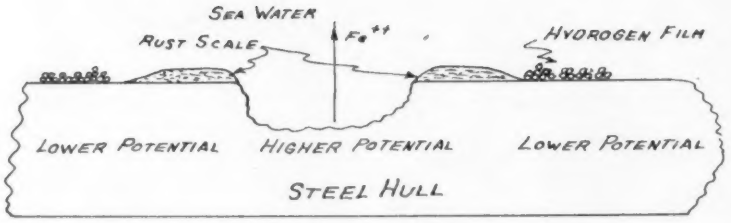
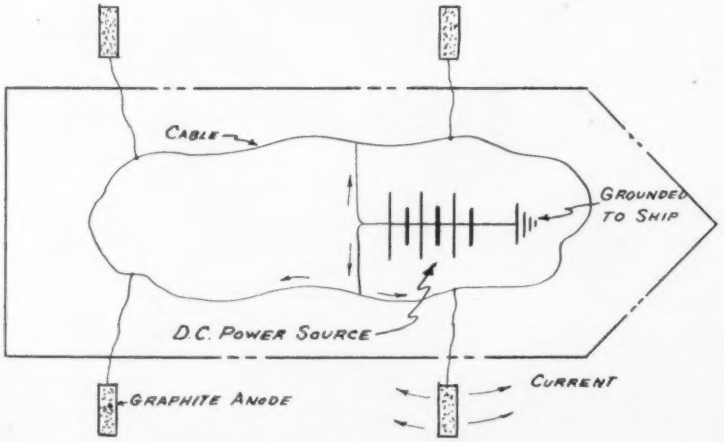


SACRIFICIAL ANODE SYSTEM.



GALVANIC CELL CORROSION.



IMPRESSED CURRENT SYSTEM.

all know that to form a galvanic current flow, we need three things: dissimilar metals, an electrolyte, and a return path for the current. However, galvanic reactions can be promoted under conditions other than those covered by two distinctly different metals, i. e., bronze propellers and steel hulls. These anodic and cathodic areas can also be formed by metallurgical or physical differences in the surface area of a metal. These differences can be caused by slag inclusions, areas of different internal stresses, weld lines, alloy inclusions and even grain boundaries, all of which can set up areas of different electrical potentials. Surface abrasions, threading, or other mechanical processes, may also cause surface differences. Any of the these can form a galvanic reaction with adjacent areas when in the presence of an electrolyte.

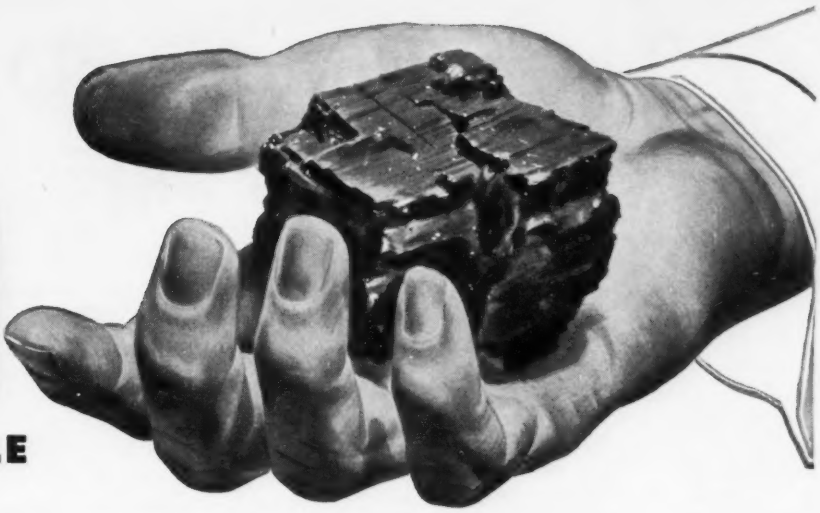
Of course the detailed reactions which occur are more complicated than can be explained in a few sentences here. However, it should be understood that (1) the underwater portion of the hulls of steel ships may have areas of different potentials; (2) sea water is an ionizable liquid; and (3) the return path for the current can be provided by the metal hull itself connecting the areas of different potentials. Thus the hulls have all the features necessary to form galvanic reactions, and as such, can contain many small cell-like areas, each do-

(Continued on page 38)

ABOUT THE AUTHOR

Oliver Bragg graduated from Cornell University with a BME degree in June 1950 and returned to active duty with the Navy as an electronics technician shortly afterwards. In a commissioned status, he has served at the Headquarters of the Atlantic Reserve Fleet in his present capacity as Hull Engineering Officer for over two years. During this time he has been intimately concerned with many facets of corrosion prevention and in particular with the installation and evaluation of cathodic protection during the major period of its application to Reserve Fleet ships.

SO MUCH FROM SO LITTLE



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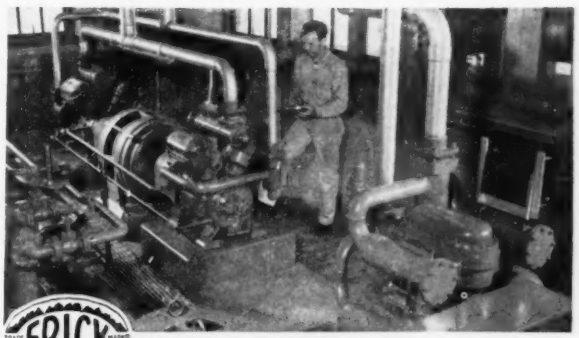

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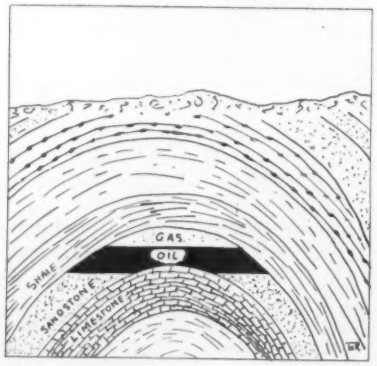
The Seismic Exploration for Oil

by THOMAS REED, ME '56

Modern man's dependency on petroleum need not be expounded to members of the engineering world. However, it is not quite as apparent that the rate of discovery of new fields must not only parallel but exceed present day consumption if we are to avoid serious depletion of our world reserves. To achieve this end, a wide variety of geophysical exploration methods have been devised.

Two of the more prominent methods, often used because of the low costs involved, are gravitational and magnetic methods. In the former, measurements are made to determine small variations in the gravitational field, indicating a subsurface density change which, in suitable areas, often infers oil- bearing structures. Gravimeters and very sensitive torsion balances are used for this work. For the latter, magnetic exploration, a magnetometer, which is really a glorified compass needle, detects minute variations in the earth's vertical magnetic field. These variations, as in the case of density changes, take on economic significance in the eyes of experienced observers.

Fig. 1. An anticlinal trap—a well known and common type that is usually detected by the reflection seismograph.



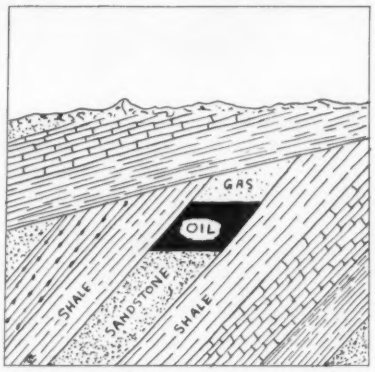


Fig. 2. A stratigraphic trap, showing regional dip and truncation of reservoir bed. A trap that is quite difficu't to detect by means of the reflection seismograph.

Relative newcomers to the field of exploration are radioactive and geochemical search methods. The former uses geiger and scintillation counters as well as a neutron source to plot structures, while the latter makes use of a chemical analysis of an area in a search for trace elements.

However, the most prominent method of all is seismic exploration, preferred because of the quality of the results and because the observed data (time, distance, and velocity) are easily converted into geologic measurements (depth and datum). It is with this phase of the search for petroleum that we shall henceforward concern ourselves.

When searching for oil, one might well ask, specifically what are we looking for? While a source rock, reservoir rock, and an impervious capping layer are necessary, the actual key to a petroleum deposit is a favorable structural arrangement of these strata that allows the oil and gas to collect. It is usually determined by geologic investigation that these three quantities are present in an area, and an exploration crew is detailed to locate the trap.

Naturally, there are several types of traps that are capable of holding petroleum deposits. One of the most common of these is the anticlinal trap, shown simplified in figure 1, which can be extended to include domes covering massive salt plugs a mile or so in diameter. So-called "stratigraphic" traps are not as easy to find as anticlines. These are produced in part by regional dip and in part by truncation of the reservoir bed at an unconformity, as that sketched in figure 2. Figure 3 shows a reef, still another type of oil-bearing formation. Here, the reef is the source and reservoir rock at the same time. There are other refinements, but the above are, in general, the targets. In order to easily show their location, contour maps of the expected oil-producing horizon, or a fictitious "phantom" horizon, are plotted. It is the correct plotting of one of these sub-surface contour maps that is the object of the seismic exploration party.

The science of seismology was initially developed in connection with the study of natural shock waves occuring within the earth's crust. However, the experience so gathered has been adapted to measuring travel times of artificial elastic waves over measured distances.

These waves, originated by explosives at a "shot point", travel in all directions from the source and, as they descend, must pass through various strata and hence across their interfaces. It is found that the velocity of propagation will

vary from one strata to another, thus reflection and refraction of these waves are bound to occur. Some waves, due to their direction of propagation, will be reflected or refracted to the surface, where they are observed by detectors. Thus, it is apparent that a subdivision of seismic exploration exists. In refraction shooting only the first refracted arrivals at large distances (several miles) are considered, whereas reflection shooting concerns itself with all the reflections within a reasonable time that present themselves to closely spaced detectors. Despite some drawbacks, it is the latter type of shooting that is most often used when in search of petroleum traps, since this process utilizes the shorter spread that is necessary to get a detailed picture of the sub-surface geology.

Seismic prospecting has thus, for the most part, been narrowed to reflection shooting, analagous to calculating one's distance to a wall by the time required for an echo to return. However, the problem is greatly complicated by the nature of the transmission medium and the difficulty encountered in recognizing a true reflection among the complex motions of the surface following an explosion.

In spite of these difficulties, however, the shooting process is just as one would imagine it to be. The first step is to cause a disturbance by means of an underground explosion. The various vibrations set up by the explosion are then recorded in terms of elapsed time from the shot moment. Now the distance or depth to the strata can be computed, through required knowledge of the average velocity of propagation. This latter information is often bought from a reliable source or determined by recording in a deep borehole, as it is indispensible in the correct interpretation of data. When this computation has been made, with proper corrections for weathering and elevation, a cross-section, simulating an actual cross-section of the earth, is made from a line of shots. Actually, a criss-cross patern of lines is shot, giving rise to a grid that can thus be used to plot the highly sought-after sub-surface contour map.

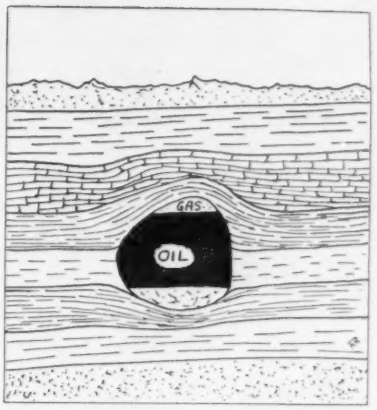


Fig. 3. Example of a reef, which quite often appears as an anticline in reflection seismograph studies.

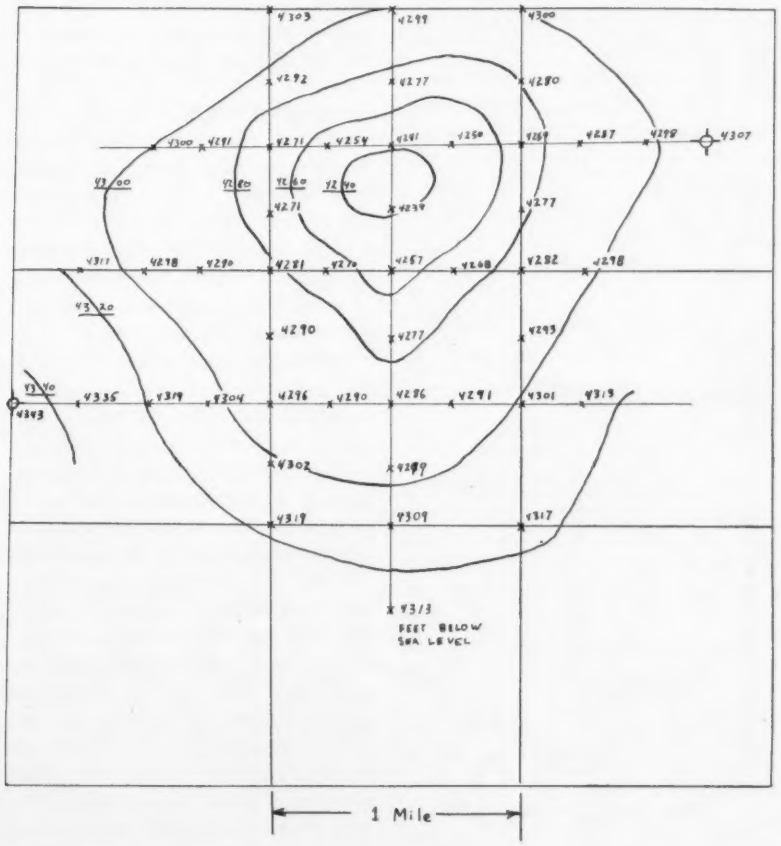
In actual practice, some of this simplicity disappears.

A reflection seismograph party is usually told by other departments in the company what area is to be covered. A map of the area is used to map out the lines to be shot, i.e., the grid pattern which will be used in the survey. When these lines have been drawn on the maps, the permission of the land owners must be secured before work can proceed further. Once a permit has been signed and damage to crops, etc., agreed upon, the actual lines are surveyed. Shot points are placed about a quarter of a mile apart, and flags are set up to show the location of detectors. Since the grids are drawn on paper in the seclusion of an office, it quite often occurs that in trying to follow a straight line for several miles extremely difficult conditions are met. Crops, water wells, ravines, houses, highways, or recalcitrant land owners often stand between theory and practice.

Once the line has been permitted and surveyed, the charges are planted. A pattern of three, five, or seven holes, geometrically placed within a few feet of each other, is often used to minimize stray surface and near-surface disturbances and thus give a clearer picture of sub-surface conditions. Likewise, the amount and depth of charge is variable. A portable rotary drill is used to drill these holes which

(Continued on page 36)

Fig. 4. Completed sub-surface contour map, showing high area for optimum drilling location.



Keeping Up To Date On
ATOMIC ENERGY II

by STUART BRAUN, ME '57

The application of atomic energy to constructive industrial and other uses has assumed wider proportions than is commonly appreciated, and is rapidly growing in magnitude with the passage of time; the stimulus offered by the enormous governmental program in the field has been mainly responsible for this progress, although privately sponsored research has definitely been a factor. However, atomic energy will not replace other forms of energy in such energy-producing processes as electrical power transmission for some time to come. The major developments thus far include the application of the phenomenon of radioactivity to uses in the medical, agricultural, pharmaceutical, industrial, and metallurgical fields, and also the construction of reactors to provide locomotion for such vehicles of travel as submarines and large surface marine craft. Reactors providing for electrical power generation, for aircraft and locomotive propulsion, are in the experimental stage and will be for another ten to fifteen years.

Radioactivity and Radioisotopes

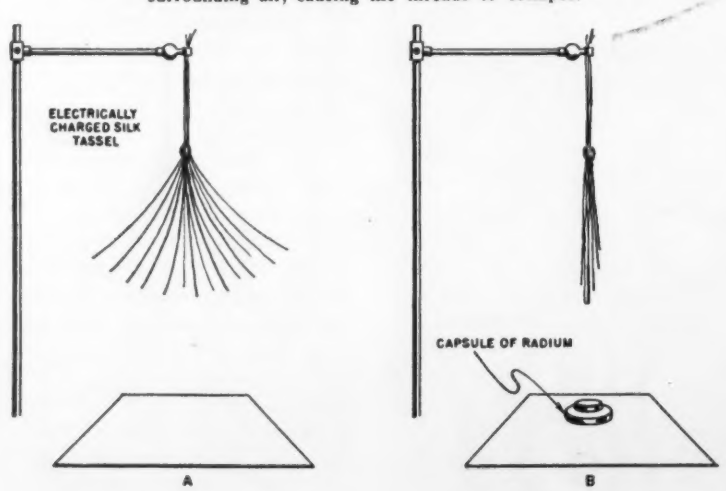
The phenomenon of radioactivity first discovered by Becquerel in 1896, paved the way for a multitude of products and processes beneficial to society, which are just today beginning to have their impact on mankind.

It was found by Becquerel and other scientists that certain elements, such as uranium and radium, give off energy in the form of radiations known as alpha, beta, and gamma rays. An atom which spews forth these forms of energy transforms itself into a completely new atom, of lower mass or charge. Some radioactive atoms give off energy at a greater rate than others, but it was discovered that the whole group of radioactive elements formed a sequence, starting with uranium and terminating with lead; that is, atoms of uranium, in an interval of millions of years, become successive atoms of different elements until they finally end up as lead particles.

An alpha ray is no more than the nucleus of a helium atom, that is, two protons and two neutrons wrapped up in one package; beta rays are negative electrons, and gamma rays are, like X-rays, high-frequency electromagnetic waves. Thus it can be seen that alpha and beta radiations have mass and charge, while gamma radiations are a form of energy like light, so that an atom giving off the two former actually is disintegrating to become a particle of lower weight than formerly. An examination of some of the properties of these forms of energy is quite interesting.

Suppose, as is shown in figure 2, we aim our alpha, beta, and gamma rays at metal sheets of increasing thickness. The alpha particles, or helium ions, traveling at about 10,000 miles per second, are able to penetrate only the thin foil, while the beta particles, speeding at velocities up to 150,000 miles per second, are arrested by the sheet aluminum, and the gamma rays are able to slip through the thick lead sheet. These radiations then differ greatly in their penetrating abilities, but subsequent experiments

Fig. 1. A source of alpha radiation, if placed under an electrified tassel, will ionize the surrounding air, causing the threads to collapse.



will prove that the least penetrating alpha rays possess far greater energy than do their cousins.

Alpha Ray Effects

One of the effects of alpha radiation which led scientists to believe that radioactive substances gave off particles which possess mass, was their ionizing power, or ability to render the surrounding air an electrical conductor. A capsule of radium, when placed under an electrically charged silk tassel, will effect the collapse of the individual threads. Also, it was found, as is shown in figure 3, that once the electrified tassel is moved to within a sufficient distance from the source of radiation, its electrically charged state is unaffected; the alpha rays are all absorbed by the air at this distance. This phenomenon led to the conclusion that these radiations must have mass, for no other explanation could be offered for their absorption by the surrounding air. As all the alpha particles have the same mass, the distance which they travel through any medium which impedes their progress must be a function of their initial velocity. Some radioactive substances emit alpha rays at higher velocities than do others, and consequently alpha radiation from different sources possess different ranges in any one medium. For example, the range of an alpha ray emanating from Thorium C is 8.62 centimeters in air, that emanating from Uranium I, 2.7 centimeters.

Another interesting property of alpha radiations is the fact that a very large surface area of radioactive material of as small mass as possible, such as a quantity of radium bromide placed on a large plate in a thin film, will emit a maximum amount of particles. It will be remembered that alpha rays are more easily absorbed by matter than beta or gamma rays. In a large chunk of the same material, as each atom emits all three radiations, more alpha rays originating from atoms within the material will be absorbed before they reach the surface than will either of the other two, while all of those emanating from atoms at the surface will reach the surrounding air; thus the amount of

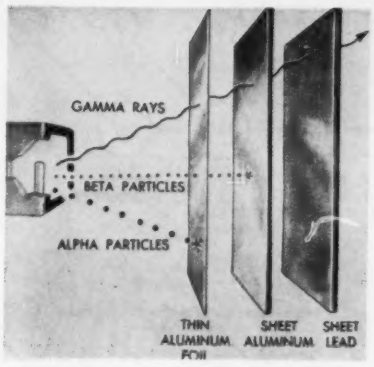


Fig. 2. An investigation of the penetrating qualities of alpha, beta, and gamma radiation shows that the latter supercedes the other two in this respect.

alpha radiation transmitted to the surrounding medium is proportional to the exposed surface area, not to the mass of the radiating substance.

Atomic Disintegration

The phenomenon by which radioactive atoms transmute themselves through the emission of alpha and beta particles, is known as atomic disintegration. An alpha particle, that is 2 protons and 2 neutrons, possesses an atomic weight of a bit more than 4. When a radium nucleus, atomic weight 226, spews forth one of these, it loses these 4 units Radium-C, of the same atomic weight 214 but with a higher positive charge than Radium-B. The disintegration continues until Radium-G, or lead, is formed. An examination of figure 4 will reveal the fact that the whole process commenced with Uranium-238, the heaviest substance found in nature.

Artificial Radioactivity

We have seen how nature allows the scientist to observe and investigate the phenomenon of radioactivity. But the scientist has not stopped there; he has been able to artificially radioactivate species of the elements which do not occur in the radioactive state in nature. These are called radioisotopes, and have been immensely beneficial to mankind in solving a multitude of our industrial and other problems.

If a cyclotron accelerated a deuteron (a hydrogen nucleus with an extra neutron) to an appreciable velocity and set it loose to bombard

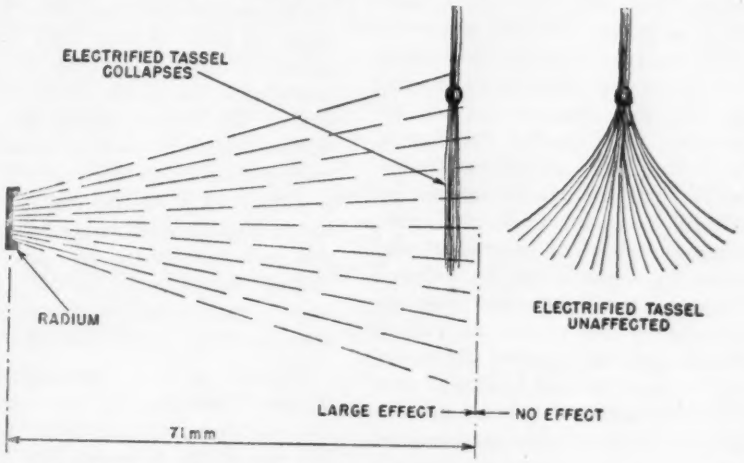


Fig. 3. The ionizing effects of alpha radiation decrease with increasing distance; the tassel fails to collapse at a critical distance from the radiation source.

of weight and 2 units of positive charge, to become a negatively charged atom of radon, atomic weight 222. This atom next throws off another alpha particle to become Radium A, atomic weight 218; again an alpha particle leaves the nucleus and Radium-B is formed, atomic weight 214. Radium-B does not indulge in alpha radiation, but in beta radiation; it loses an electron to gain a positive charge of one. The loss in mass is negligible, and we call the resulting atom a sodium nucleus, a radioactive isotope of sodium would be produced. The proton and neutron in the deuteron split as soon as the sodium nucleus absorbs the particle, the proton flying out while the neutron remains within the nucelus.

$$_{11}Na^{23} + {}_{1}H^{2} \rightarrow {}_{11}Na^{24} + {}_{1}H^{1}$$

The sodium isotope Na^{24} possesses more mass than previously; exactly by that of the neutron. This isotope is unstable and undergoes beta decay, emitting an electron:

$$_{11}Na^{24} \rightarrow {}_{12}Mg^{24} + {}_{-1}e^{0}$$

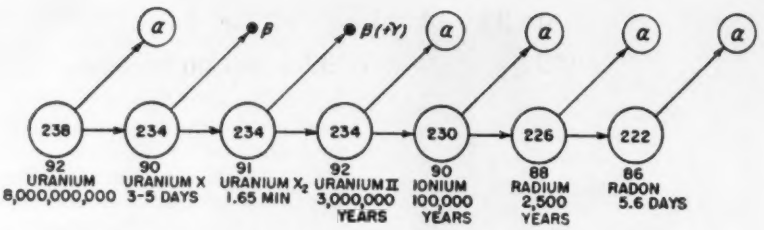


Fig. 4. The transmutation-by-radiation process is shown here to commence with uranium-238, to end with lead.

to form magnesium. Over 500 radioisotopes have been similarly produced, and of these there exists at least one for every element.

Use of Radioisotopes

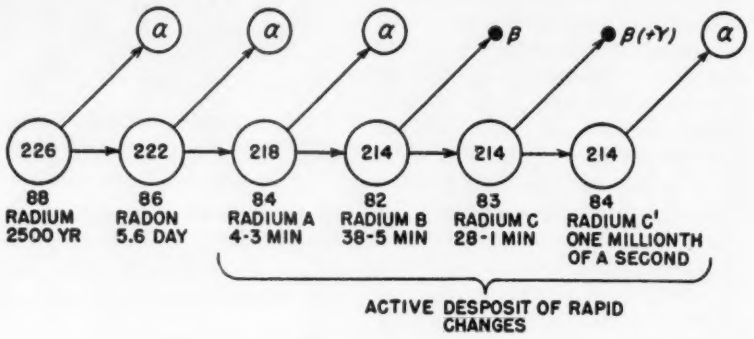
What makes radioisotopes such a boon to humanity? First, they may be employed as radiation sources, and their radiations may be used to destroy malignant tissue in the human body. Chemically identical with other isotopes of the same element, they can be taken into the body without injurious effects, where they emit their beneficial radiations and disappear within a matter of days. Secondly, their radiations can be easily detected by extremely sensitive devices; the presence of as small a quantity as a trillionth of an ounce of radioactive material can be located by Geiger counters. Their course through chemical reactions and other processes can be followed closely. This is the tracer type application. The advent of nuclear reactors, whereby atoms are exposed to neutron bombardment and rendered radioactive, made possible the manufacture of large quantities of radioisotopes; previous to the development of the reactor, only very small quantities could be produced by cyclotrons and other particle-accelerating instruments. Since 1946 the AEC has made over 39,000 shipments of these materials to research institutions and industrial firms.

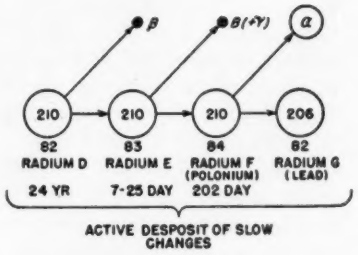
Measurement Devices

Thickness gages: Over 200 manufacturers in this country are employing these devices to measure the thicknesses of such materials as sheet metal, paper products, plastics, and fibers as they come off the production lines. The amount of alpha, beta, and gamma radiation absorbed by the sheets is translated into thickness measurements. In addition, coatings such as paints can be gauged very accurately. Two types of such devices have been perfected: backscatter and absorption gages, illustrated in figures 5 and 6. The former utilizes the reflected radiations, so that access to only one side of the material is required; while in the case of the latter, the material passes between the radiation source and the detecting mechanism. These gages employ radioactive strontium, cesium, or cobalt as radiation sources.

Specific gravity measurement: Figure 7 illustrates the use of gamma radiation to measure the specific gravity of a liquid. The rays enter the solution at an acute angle, and are scattered throughout the fluid, the amount of scatter being a function of the density of the fluid. Part of the radiation is "backscattered" to the Geiger-Muller counter, which is connected to a meter which translates the backscatter into terms of specific gravity.

Liquid level gage: This device, shown in figure 8, has been extremely useful in measuring the height in a tank of a highly corrosive liquid which cannot be exposed to the air. A vertically moving float containing a gamma emitter, moves with the top level of the liquid. As the distance between the emitter and the Geiger counter at the top of the tank increases, the reflected radiation changes accordingly, and this change is indicated on the appropriate meter.





Radiography

Radiography is a method whereby structural defects in materials are easily detected without changing the character of the specimen. Radiations directed on, let us say, a ferrous casting or a weld, are absorbed to the greatest extent by the more dense areas of the material. On a photographic film placed behind the casting or weld, are revealed dark and light areas, the lighter depicting the denser or thicker sections of the specimen. By this process such defects as cracks, inclusions, and shrinkages in castings can be located before wasted resources are expended on machining a faultily cast product.

Other Applications in Industry

Friction and lubrication: Tracers have been used to measure the frictional wear upon a machine part. In a typical experiment, automobile engine piston rings are made radioactive and then installed

in the engine. After a few hours' operation, a sample of the lubricant is inspected; the radioactivity of the oil is a measure of the wear of the rings. The process enables lubricant manufacturers to test the quality of their products and automobile fabricators to determine the durability of their engines.

Petroleum product flow: Petroleum manufacturers are especially interested in locating the interface between two petroleum products flowing through an overland pipe, so as to map out routes for them toward different take-off points and terminals along the line. This is effected by injecting a small quantity of radioisotopes at the interface at the origin of the line, and observing their course as they travel through the pipe, with Geiger counters located at various points along the line. The same principle is employed to locate leaks in underground water pipes and mains.

Applications in Medicine and Pharmacy

The use of radioisotopes in treating fatal diseases and perfecting healing drugs has drawn closer the day when such maladies as cancer and anemia will be treated successfully. The boon to research afforded in the medical field by the discovery of radioisotopes cannot be overemphasized.

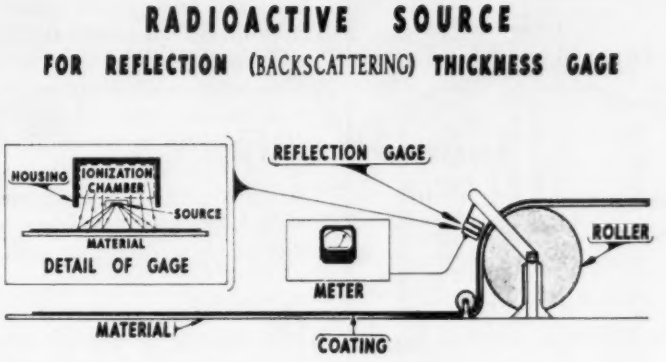


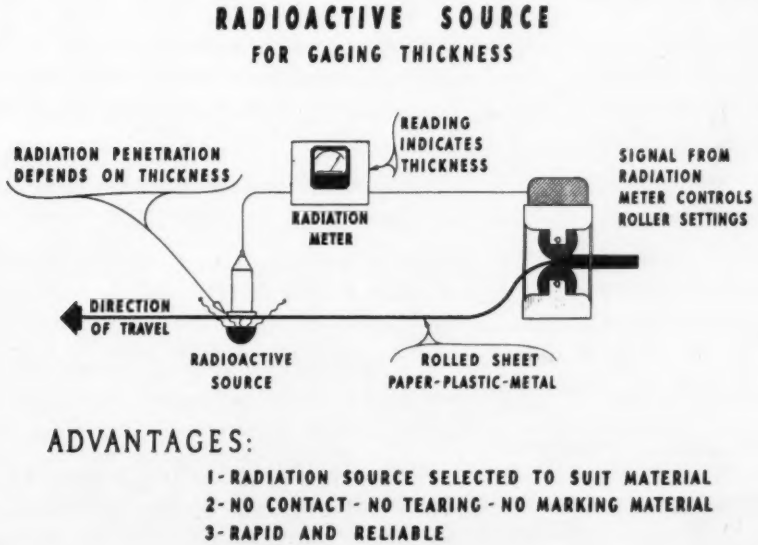
Fig. 5. The major elements of a backscatter thickness gage are shown here. Radiation source and detector are located on the same side of the material; thus, accessibility to only one side is required.

The treatment of cancer has received wide attention as regards radioactivity. Radioiodine taken into the body will be absorbed by a cancerous thyroid gland, and there will be able to destroy the cancerous tissue through its radiations. Other infected glands which exhibit affinities for certain substances can be treated similarly.

Tumors of different types, unable to be located by ordinary means, can be located during surgery by following a radioisotope to the malignant cells. Radioboron injected into the bloodstream will accumulate at tumorous brain tissue; it is then exposed to neutron bombardment from a reactor. The boron atoms split apart, each fragment acting as a tissue-destroying form of radiation. Radiophosphorus and radiogold have also received wide use in the medical field.

The development of drugs and medicines to treat disease has been furthered by the ability of the research technician to "perceive" the effects of certain compounds on the body tissues and blood stream through radioisotopes. The use of radiocarbon, radiozinc, and radioiron has led to the discovery of drugs to fight anemia and diabetes. In addition, the fundamental processes of the body itself can be more completely analyzed. For example, the rapidity with which salt diffuses through the veins, travels to the sweat glands, undergoes conversion to sweat and appears on the outside of the body has been accurately timed. The cycle is completed in less than a minute, a fact unknown previous to the advent of the application of radioisotopes.

Fig. 6. Absorption thickness gages require accessibility to both sides of the material being measured.



Applications in Biology

The use of radioisotopes in the biological field has enabled man to better understand the processes of the human body and of other living

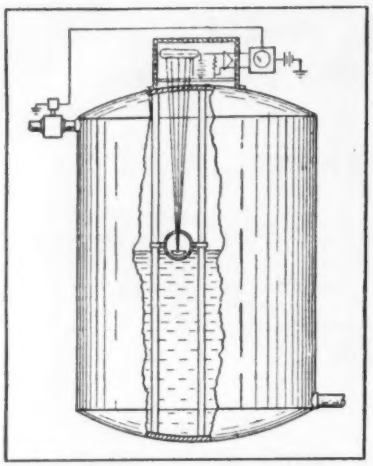


Fig. 8. A gamma ray emitter moving on vertical ways is the principal element of the liquid level gage.

organisms such as plants. For example, the injection of Fe^{59}, Cl^{38}, Ca^{45}, P^{32}, and N^{15}, into the body have afforded biologists the chance to study blood circulation, cell properties, excretion products, and protein and phosphorus metabolism.

The enigma of photosynthesis, the most fundamental life process of plants, the mechanism of which has long been a mystery to biologists, has been partially uncovered as a result of experimentation with radioisotopes. This process, by which plants utilize water, carbon dioxide, and the sun's energy to build up protein, fats, and carbohydrates, is the source of all our food and fuels. Plants grown in an atmosphere of carbon dioxide containing radiocarbon provide scientists with an excellent opportunity to determine how food and fuels are fabricated by nature within a matter of minutes. If the process should some day be completely analyzed, it may be possible to manufacture food and fuel artificially.

Agriculture

Work with isotopes in the field of agriculture has uncovered facts which will enable farmers to better utilize fertilizers, grow crops more efficiently, and guard against plant diseases. For example, radioisotopes have revealed that certain crops utilize fertilizers more efficiently than others; that the nature of the soil influences fertilizer efficiency, that certain phosphates are more effective fertilizer ingredients than others. One project in North Carolina saved that state's farmers over 4300 tons of superphosphate a year; experiments demonstrated that tobacco plants could not avail themselves of fertilizers deposited on the soil surface during the growing season.

The benefits so far realized from the phenomenon of radioactivity are multifold and ever-increasing; however, with the advent of the Atomic Energy Act of 1954, another application of the atom's might is coming into the limelight to overshadow all other applications: the generation of locomotive and electrical power.

Nuclear Power Plant

The next ten years will undoubtedly see the installation of power plants utilizing nuclear fuels producing electricity to replace conventional facilities using coal and other fuels today. These plants will of course "burn" either of the three fissionable materials, U-233, U-235, or Pu-239, in so-called reactors, mechanisms for the production of heat from nuclear fuels, discussed in a previous article on atomic energy in this magazine. A cooling medium such as water or liquid sodium will circulate through the reactor to carry off the generated

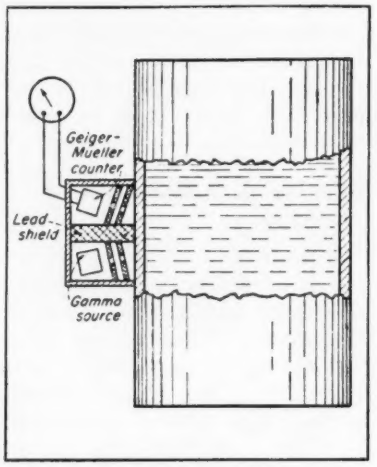


Fig. 7. The amount of radiation reflected by a fluid is translated into terms of specific gravity by this device.

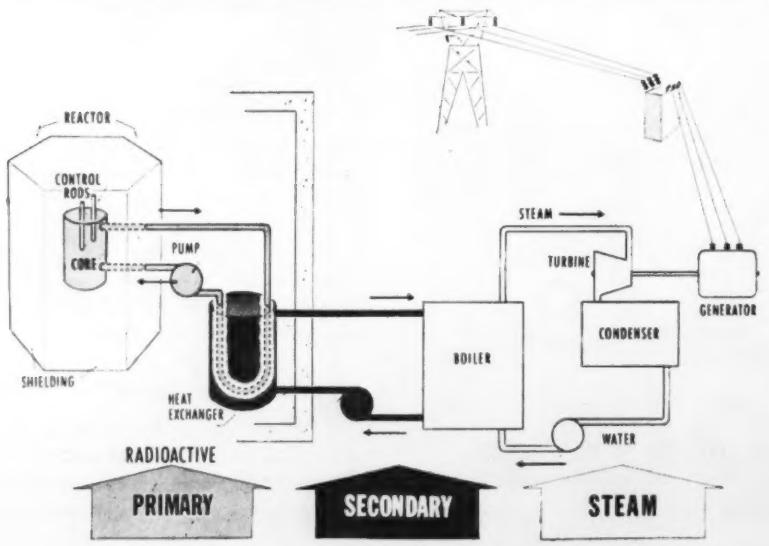
heat. A heat exchanger will transfer the heat from the radioactive coolant to a boiler, where steam at high pressures and temperatures will travel to a turbine which will in turn drive a generator producing usable electric power.

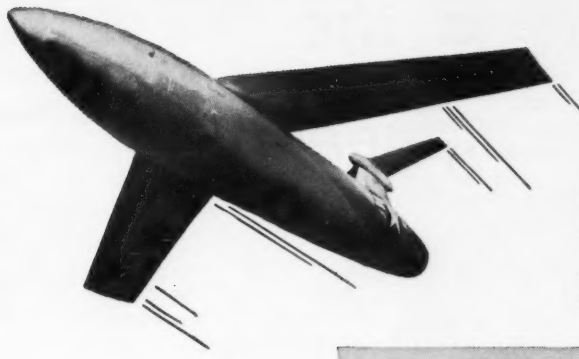
Reactors have been constructed which have produced usable power, but at an extremely uneconomical rate. The experimental Breeder Reactor at the AEC's Reactor Testing Station in Idaho drives an electric generator with a capacity of 250 kilowatts, enough power to supply several blocks of homes. Other low-capacity generating reactors have been constructed, but these are strictly experimental and do not begin to approach practicality from the economic standpoint. Moreover, it is generally conceded that at best

(Continued on page 42)

Fig. 9. A simplified sketch of the atomic power plant.

NUCLEAR POWER PLANT SIMPLIFIED SCHEMATIC



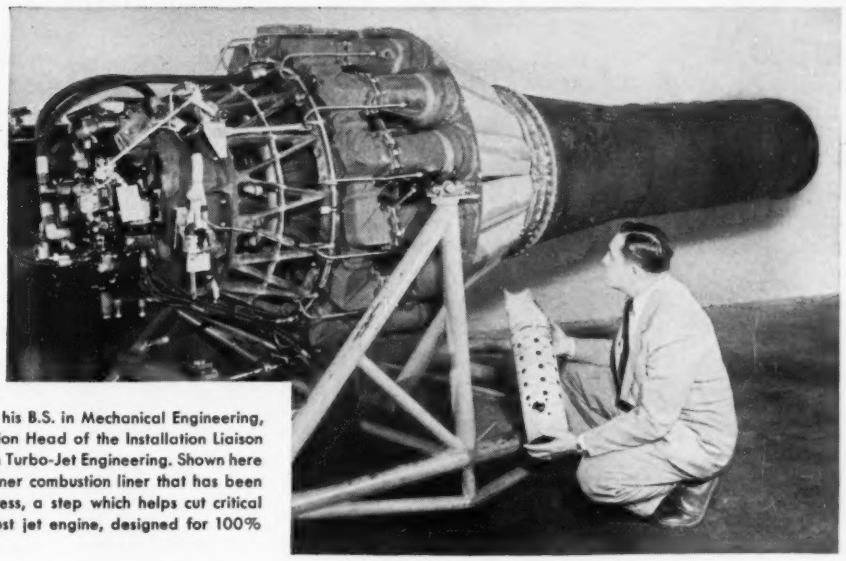


ALLISON

Engineers Pioneer

MISSILE

Power Plant Development



W. S. "Gus" Broffitt, who received his B.S. in Mechanical Engineering, U. of Kentucky in 1938, is now Section Head of the Installation Liaison and Engineering group of the Allison Turbo-Jet Engineering. Shown here by a J33-A-37, he is holding an inner combustion liner that has been through the aluminum dipping process, a step which helps cut critical materials in this high speed, low cost jet engine, designed for 100% reliability.

● The Allison jet powered USAF B-61 Martin Matador is the country's first operational ground-to-ground pilotless bomber. And, it's the first such missile to be sent overseas for duty.

The B-61 engine—an Allison J33-A-37—is based on the proven Allison centrifugal flow engine. This engine has accumulated more than 2½ million hours of flight in such aircraft as the Lockheed F-80 Shooting Star, the T-33 Trainer, F-94 Night Fighter, and in the Grumman F9F Panthers and the Cougars!

In 1950, Allison undertook the project of engineering and developing a 5-hour, low-cost, expendable jet engine for the Glenn L. Martin Co. which was under contract with the Air Force. The missile assignment made it necessary for Allison to design a J33 model—incorporating reduced material, manufacturing and testing costs—and still maintain a 100% reliability.

The concentrated efforts of Allison engineers resulted in an 85% reduction of critical materials in missile engines in comparison with the similar centrifugal flow engines built for piloted aircraft.

An aluminum dipping process, developed by Allison engineers—in cooperation with General Motors Research—helped materially in reduction of critical materials. This process was used on inner combustion liners and permits using a low alloy steel in place of highly critical material. The aluminum dipping process affords corrosion protection, and still enables the liners to withstand high combustion temperatures. First to use aluminum dipping equipment on large parts, Allison now uses the process on turbine engines scheduled for piloted aircraft.

The missile power plant project is another example of the variety of problems handled by Allison engineering. Because Allison is continually doing pioneer work in advanced engineering developments, we need more technically trained men, especially young graduate engineers. Want to know more about your engineering future at Allison? Write now for information:

R. G. GREENWOOD, Engineering College Contact
ALLISON DIVISION, General Motors Corporation
Indianapolis 6, Indiana

Senior Projects in the College of Engineering

by ARTHUR H. VAUGHAN, E.P. '57

Five schools in the College of Engineering require their students during their ninth and tenth terms to undertake and complete an advanced original project in some field of engineering or science. Because these projects afford valuable practice in the applying of classroom knowledge, often for the first time, and also require some rather careful selection of topics and experimental methods, we present here a few items of information and interest extracted from students who are now involved with projects, and from their advisors, for the benefit, possibly, of impatient underclassmen.

Some of the questions which may be asked, whose answers will be found in the following paragraphs, are these: (1) How do you determine your choice of a project, what should it involve, and how do you get started? (2) How are the projects organized, with respect to working space, assistance, time reports, etc. . . .? and (3) What are some of the things men are doing now as projects?

Selection of Projects

Although selection of projects is a decision the student is asked to make himself, according to his own interests, each school has a list of available projects which may make the choice easier, and a student may consult the faculty for assistance in settling on a project. There exists certain special "minimum" requirements on projects, however, and it is well to have these in mind when considering the subject. For example, in Chemical Engineering, the student must plan to do work which involves actual construction and manipulation of equipment, whereas in Engineering Physics, projects in pure theory are acceptible (although not necessarily the general rule). In Mechanical Engineering it is possible to carry out a project involving the design of equipment which the student himself does not build. The criteria for choosing a project do in fact vary among departments and among students, and often turn out to be something of a personal matter. It is generally considered wise to pick a project which is interesting (such as might have been encountered in a summer job), which fulfills the pertinent requirements, and which is about as difficult a job as the student thinks he can properly handle. Conference with staff members who handle projects can often be very helpful. In Chemical Engineering, again, students begin talking about projects in a seminar course during the last half of the eighth term, during which time the projects and the staff project advisors are assigned, partners picked (two men per project in this case), and objectives, problems, and special equipment are considered in a preliminary report. In other departments such a course is not held formally, but rather project selection is handled privately.

Since summer intervenes between choosing and beginning of a project, this time may often be profitably spent in catching up on literature available in the topic chosen. This is of course not required, but

Marshall Lapp, with his project, shock tube apparatus.

—Steve Beck

the procedure has been followed many times, with consequent saving of confusion at the onset of term nine.

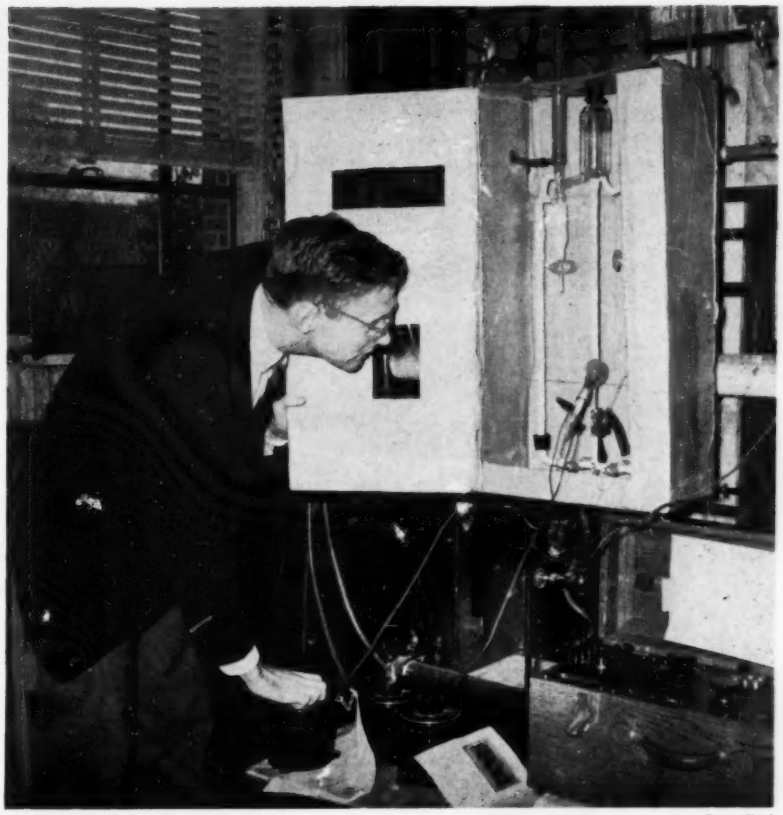
Organization

In carrying out his project a student may work alone, with a project partner, or with a small group, depending upon the nature of the work. If one man can handle it, he ought to do so. In any case, it is important that each member of a research group supply his share of ideas and labor, the reasons being obvious.

Each project is advised by a member of the faculty in whose field the topic of the project lies, no advisor having more than about three to five projects under his jurisdiction. He may be consulted from time to time about the work. However, to simulate the conditions with which the student will meet later as an employee, the advisor will tend to remain somewhat aloof to questions asked him about the actual research problem, at least during the first stages of the work. He is willing to be consulted about details not related directly to the project. If the student is putting full effort and originality into his project, the staff is quite willing to give a hand in difficult prob'ems, since, inevitably, things do not always work out as nicely as they are planned.

Funds for equipment are supplied by the University, and in this connection the advisor will arrange a budget to fulfill the expected expenses, within moderation, of the project; the expenses might run anywhere from $10 to $100. In rare cases, an organization outside the University (such as an industry) may become interested in sponsoring a particular project, type of project, or an individual with whom they have contact, this being in the form of a scholarship. In such cases the organization may furnish some of the required equipment. There are available certain pieces of equipment which have been furnished by industries for general use in project work. Arrangements about these topics are usually made through the project advisor.

An example of a sponsored project is being carried out under the Department of Thermal Engineering (formerly known as Heat-Power) on a problem in passenger-car air conditioning refrigeration systems. Actual performance of some equipment supplied by Bendix and Chrysler, who are interested in the results, will be compared with that predicted by analyses of simulated cycles involving a 4-cylinder Freon-12 compressor. Five students are occupied with this project.



—*Steve Beck*

Edward R. McDowell, Chem.E. is shown here with apparatus for his project in fractional distillation.

Starting the Work

After a student registered for senior projects has selected his topic, he needs to outline for himself (and advisor) his proposed procedure for undertaking the work. This will involve a good familiarity with the topic. The student, with his project advisor, must decide upon a place where experimental work may be set up. Chemical Engineering provides working space in small research rooms located in Olin Hall, two projects per room. Students are furnished with keys for the building, research room, library, and other necessary spaces. One may sleep with his project if he so desires. EP projects are usually carried on in Rockefeller. It is sometimes possible to arrange to do a project with a department other than the one in which the student is registered. Such arrangements are made through the faculty after the project topic is chosen, the location being determined by the department to which the project advisor belongs.

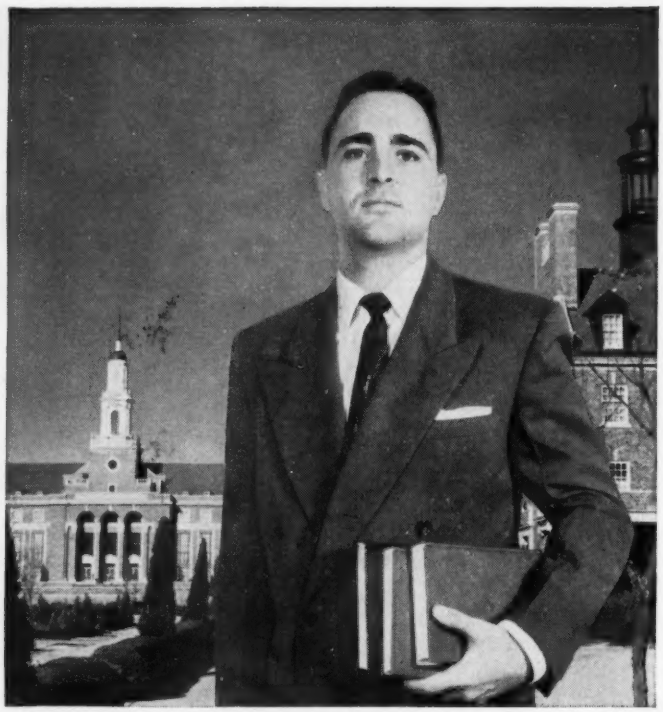
Records and Reports

It is usually suggested, if not required, that a student keep for his own use a notebook containing all notes, scratch work, and rough data pertaining to his project. In this he records "everything he does". The proceedure here is identical with that followed in industrial projects, because, in the event of patent application, such sets of notes serve as direct evidence of the work being performed according to the claim. In addition, here, the notes permit the advisor to keep track of the student's progress if he wishes to do so.

(Continued on page 54)

"Dress" Pruett wants to know:

What type of training program does Du Pont have?



DRESSLAR M. PRUETT expects to receive his B.S. in Industrial Engineering this summer from Oklahoma Agricultural and Mechanical College at Stillwater, Okla. He is president of the local student branch of A.I.I.E. Naturally, he is interested in selecting the best job opportunity for a successful career based on his technical training.

DONALD C. MILLER received his B.S. in Chemical Engineering from Ohio State University in June 1937. During the following month he started work with the Organic Chemicals Department of Du Pont at Deepwater Point, N. J. Since then he has received and given many kinds of technical training. Today Don Miller is a general superintendent at Du Pont's Chambers Works—well qualified to answer questions about training programs for college men.

Don Miller answers:

Training has many facets in a big firm like Du Pont, Dress, and a great deal of thought has been given to make it truly effective. We look upon training as a very important factor in a man's career. We think that the best way to train a college graduate is to give him a maximum of on-the-job responsibility in a minimum length of time. That's the general guiding policy at Du Pont, Dress.

Of course, each department varies this general policy to suit its special needs. A new man being trained for production supervision may first spend a year or so in laboratory or plant development work. Or he may spend his training period as a plant operator. Thus a man obtains firsthand knowledge of his process, and establishes a bond of mutual respect with the men he'll be working with on his first major assignment.

A young man interested in sales is often first assigned to a plant or laboratory dealing with the products he will later sell; or he may join a group of trainees to learn selling techniques right from the start.

An engineer, chemist, or other technical graduate is usually chosen for a specific job within his major field of study. Such a man brings specialized knowledge and skill to his job, and he is encouraged to put them to use promptly. But at Du Pont his experiences on the job are supplemented with lectures, conferences and discussion groups. In a very real sense, new technical employees continue training in their specialties after joining the Company.

To sum it all up, Dress, Du Pont's training program is individualized to provide a new man with specific opportunities to learn from contacts with more experienced men. The *prime objective* of Du Pont training is always kept clearly in mind—to develop men for future advancement and effectiveness in the organization.

NOW AVAILABLE for student ASME chapters and other college groups, a 16-mm. sound-color movie—"Mechanical Engineering at Du Pont." For further information write to E. I. du Pont de Nemours & Co. (Inc.), 2521 Nemours Bldg., Wilmington 98, Delaware.

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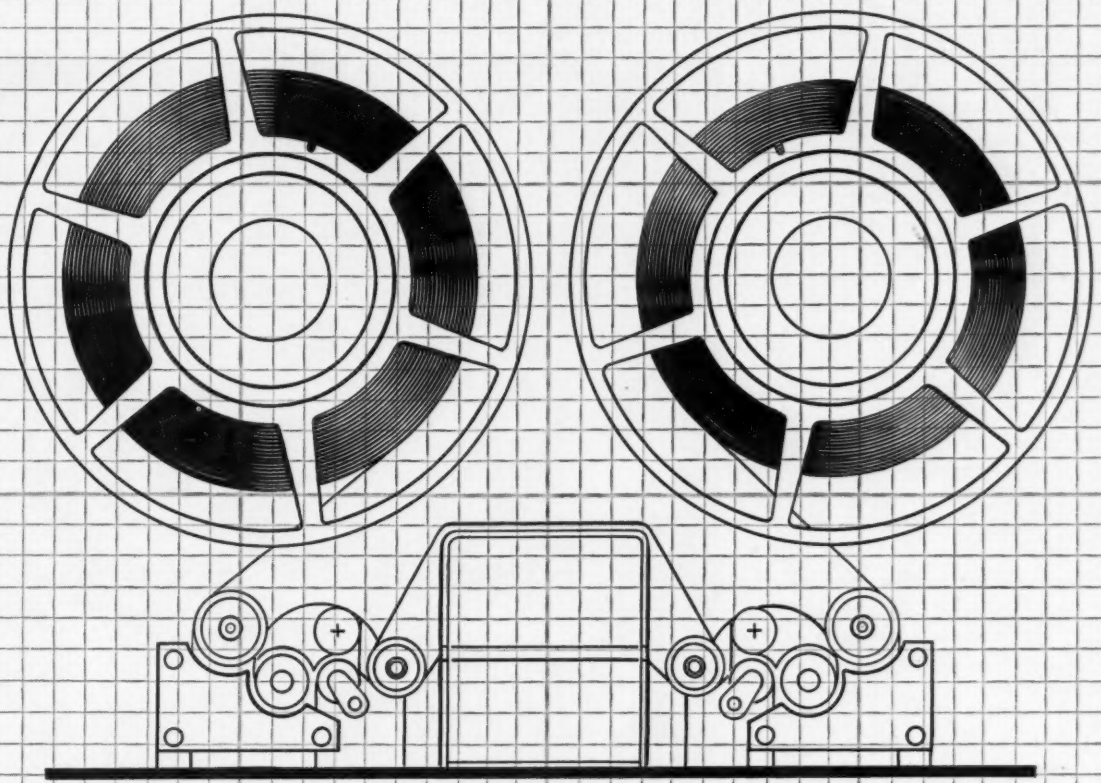

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High Voltage Lab Expands

by RICHARD BRANDENBURG, EP '58

Cornell University's High Voltage Laboratory is a workship that is being prepared for expanding studies of large scale electrical phenomona. The Laboratory is housed in a giant box-like building on Mitchell Street, near the outskirts of Ithaca. Research projects and development of test equipment are under the direction of Professor S. W. Zimmerman of the School of Electrical Engineering. His thorough knowledge of each lab machine, and his enthusiasm for every detail of the layout reflect the spirit of constant improvement that marks the activities of the High Voltage Lab.

The Laboratory began in 1940, when five companies, including Corning Glass Co., Porcelin Insulator Co., Lapp Insulator Co. Aluminum Co. of America, and the General Cable Co. conceived the facilities of a high voltage laboratory. From 1940 to 1945 a variety of tests were run involving high voltage electrical phenomona. Artificial lighting was produced using 25,000 amperes of current and forming a fifteen-foot surge at 3 million volts. In testing industrial equipment, artificial rainfall was made in the lab to simulate operational conditions. Factors such as drop size, angle of rainfall, and conductivity of water were accurately controlled.

Insulators were subjected to rigid tests as a part of investigations into the characteristics of electrical equipment. Sufficient voltage was applied to cause the air and the insulators to act as conductors, rendering the insulator itself ineffective. Transformers were tested under standard conditions, and transmission lines and associated structures were subjected to flashover. The Laboratory utilized its own wood-treating water extraction oven to prepare the wood used in test apparatus for high voltage conditions.

—Matt Starr

Interior of the high voltage lab, showing the unloading of heavy equipment from flatcars with twenty-ton overhead crane.

On February 12, 1948, fire completely destroyed the original High Voltage Laboratory. Since that time a new structure has been built and a constant process of machinery aquisition and construction has reestablished the High Voltage Laboratory as a valuable research and instructional tool. The building itself consists of office space, a control room that is now serving as a machine shop, a darkroom, and the testing area itself. The test area is a cavernous room measuring 120 feet long, 60 feet high, and 70 feet wide. A rail siding enters the building through a 24x30 foot freight door. The rear wall of the test room contains a 60x30 foot door to allow test equipment movement. A crane with twenty ton and five ton capacity hooks is mounted on the ceiling. Running up the side of one wall is a monorail lift, designed to transport observers to catwalks and platforms near the roof that provide an overall view from above the operations on the test room floor.

A variety of machinery, projected to be used for testing purposes, jams the test floor area. Several large generators, eventually to be utilized in providing necessary variable voltage—variable frequency output for tests, are protected by a thermistor bridge circuit from adverse effects near dew-point temperature. The circuit is arranged such that a temperature variation of several

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degrees in the dew point range outside the lab will actuate a circuit that triggers a bank of infra-red lamps focused on the base of the transformers. The heat generated reduces the sweating condition. Other lab equipment includes a large 60-cycle high voltage transformer, the oil for which is tested in the laboratory for effective use within the appartus.

Other test equipment includes a student-built device that combines a Marx and a Cockroft-Walton circuit to deliver either pulse D.C. or sustained D.C. as determined by the operator's control setting. There is a load-testing machine that has an insulated top end, enabling a 25 ton load to be applied to a structure simultaneously with 100,000 volts. A generator, formerly driven by a steam turbine to provide municipal electricity, hae been modified to be coupled with a 300-horsepower dynamometer that will be used to power the generator. A large metal storage shed is located near the Laboratory to house the overflow of equipment that is slated for future application in testing research.

The site for the High Voltage Laboratory was chosen for two reasons that enhance its testing flexibility. An abondoned railroad bed runs out from the rear of the building, providing a pathway of over a quarter of a mile of University-owned land that can be used to erect transmission line towers for full scale power transmission studies. In addition, the Laboratory is in an area exposed to lightning, desirable for first-hand calculations of lightning effects.

In considering the goals and achievements of the High Voltage Laboratory, Professor Zimmerman outlines a variety of problems that have been and will be met for industry. The effects of paint spattered on transmission tower insulators have been analyzed recently. Rope manufactures desiring to produce a rope that is safe for linemen to use under high voltage conditions would find help from the laboratory in introducing an extra safety factor in their product. Transformer protection and insulator problems will be explored. The possibility of efficient paint spraying techniques, using electrically charged paint, is typical of future studies to be made in the Laboratory. In addition, statistics of lightning currents and frequencies will be investigated.

The High Voltage Laboratory fills an active educational roll as a part of the school of Electrical Engineering, in addition to its industrial research efforts. Classes in high voltage phenomona are held in the Laboratory. Following its total destruction by fire, the High Voltage Lab has been rebuilt in six years by Professor Zimmerman and his assistants Russel Boyer and Ensio Koski. Today the Lab stands on the threshold of innumerable practical applications in electrical engineering.

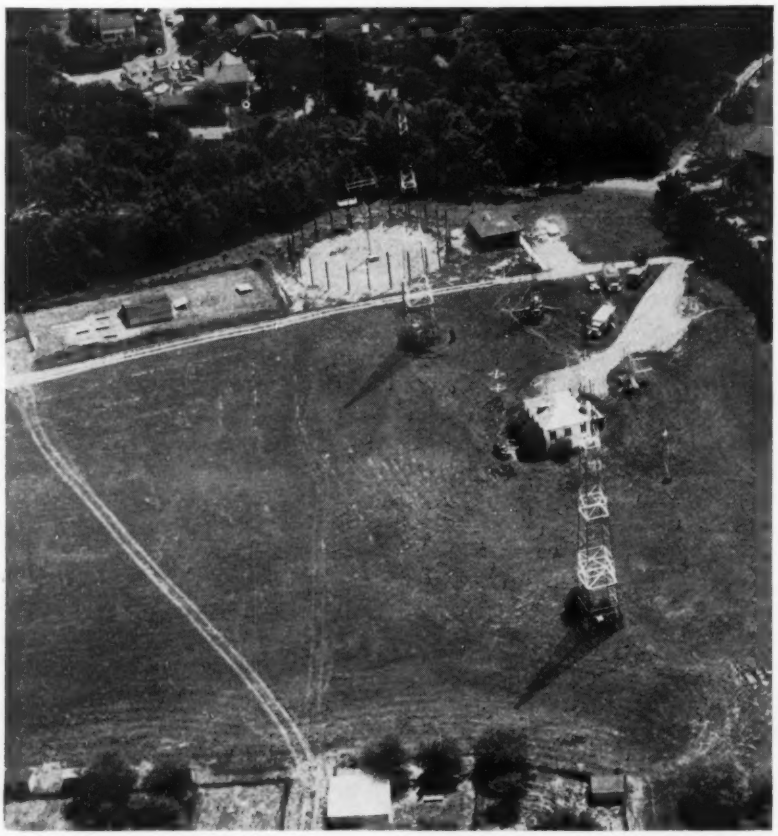
Probing the Ionosphere

by RICHARD BRANDENBURG, EP '58

The School of Electrical Engineering at Cornell is conducting fundamental research into the nature of the ionosphere. An investigation of the ionized region of the earth's atmosphere above an altitude of 60 miles reveals that aurora, or Northern Lights, are detrimental to communication. Recent studies show that the ionosphere is not, as was formerly believed, a uniform medium, but rather contains irregularities that also affect communications.

The Cornell research has been carried on for the past five years under an Army Signal Corps contract. Visual and radar methods have been used to probe the relationship between the ionosphere and communications. Information has been obtained on the nature of the aurora, its structure, rate of motion, and the mechanism of ionization production. Radar mapping of the aurora has provided data in spite of adverse weather conditions. Such mapping has revealed that aurora effects, rather than being independent of the time of day, occur with greatest frequency at night. Radio amateurs operating in very high frequency bands have provided additional data about wave propagation during contacts by pointing their antennas north to utilize the aurora.

Aerial view of ionosphere study testing facilities, located near the Kline Road dorms.



The ionosphere studies have been under the direction of Professor H. G. Booker, recognized as a world expert in the field. The program, initiated by Professor Booker six years ago, was set up as a means for support of graduate student research. Cooperating with Professor Booker in the administration of ionosphere research is Professor B. Nichols, who has been connected with the project for the past three years.

Experiments have been made involving the measurement of television and frequency modulation signals that are propagated by the aurora. A station operated by the Bureau of Standards in Cedar Rapids, Iowa, is in operation twenty-four hours a day throughout the year, transmitting signals for experimental analysis. Plots of auroral effects on transmission indicated that auroral conditions are at a maximum at the time of equinox, and at a minimum during periods of solstice. Recent tests indicate that echoes of the type desired for long distance signal transmission can be obtained when receivers are directed normal to the magnetic field of the earth at a height at which reflection occurs. Charged particles from the sun create rays of ionozation in the atmosphere that line up according to the earth's magnetic field, such that maximum energy scattered from the rays is received when a position normal to the field is assumed.

The School of Electrical Engineering and the Signal Corps want to lick the problem of auroral interference and variation. In finding solutions to the problem, a theory of scattering based on irregularities

of medium, developed by Professors Booker and Gordon, has been applied to the ionosphere. It has been predicted that auroral scattering of high frequencies can be given practical application in communications. Studies of ionosphere irregularities using radar techniques have shown the most accurate measurements can be obtained by looking directly up at the medium in question. This method of direct vertical incidence has been used for Cornell studies, with the 200 kilowatt transmitter and 100-foot paraboloid antenna located near the Kline Road dorms. A transmitter in Cortland that is operated by microwave remote-control from Ithaca is used to study the effects of ionosphere disturbance on radio transmission.

Combining a practical desire for improved communications with exploration into fundamental physical phenomena, the Cornell ionosphere research program is penetrating the mysteries of the upper atmosphere. The relationship between solar activity, like magnetic storms, and auroral effects is known but not fully understood, while the effects of meteors and the earth's magnetic field upon the extent of ionosphere irregularities require further investigation. The Cornell project is a significant effort in providing greater understanding of the ionosphere and relating that understanding to engineering problems.

The 100-foot parabolic antenna used for direct incidence studies of the ionosphere.

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Implications of Specialization

by A. ROBERT HOLTZAPPLE, Arch '55

The Cornell Engineer takes great pleasure in presenting the Cornell prizewinning Tau Beta Pi essay "Implications of Specialization." The author, A. Robert Holtzapple, is enrolled in his fifth year in the College of Architecture and was initiated into Tau Beta Pi on December 12, 1954.

Specialization and civilization are mutually associated—both are offsprings of technology. The rise of civilization can be called a technological adventure, an economic enterprise. The inventions and discoveries of the past and present enable men to satisfy their physical wants more efficiently and in the comfort, leisure and relative security thus achieved they are able to develop social graces, fine arts and literate learnings.

In all civilization before our own, agriculture furnished the chief source of wealth; practically all aristocracies were based on land, and agriculture boasted more prestige than commerce. There is no doubt that the ruling classes of these previous societies enjoyed their wealth but they were nearly all contemptuous of the artisans and merchants who provided it for them. Despite this handicap, industry and trade flourished—and so did civilization. The last century, however, has seen a curious turnabout—business and technology are now generally honored above all other activities. Never before has a technician occupied such an influential position in society.

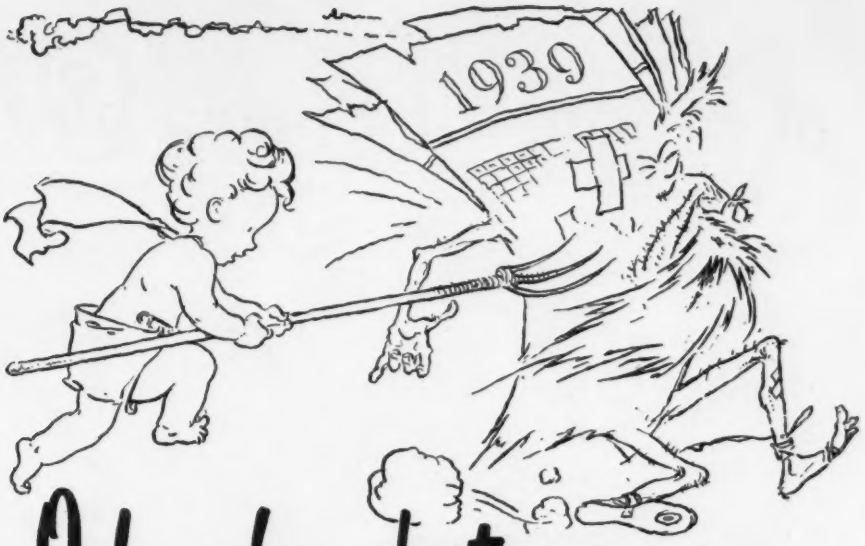
The sudden advances of technology and the accumulation of an economic surplus have brought about a division and diversification of labor—specialization. Unfortunately, men are apt to underrate the fabulous gains this has made possible. Many persons, resenting their confinement to a particular task or regretting their dependence, are fond of cultivating the illusion of being as self-sufficient as their pioneering ancestors. Yet specialization —by the individual and the community—is clearly the index of human development.

A. Robert Holtzapple

The self-sufficient person can make little contribution to the community — the self-sufficient community can make little contribution to other communities. Specialization alone has enabled the extraordinary man to discover and develop his genius—the ordinary man to develop his individuality. The technically minded man of today *must* be a specialist if he is to make his maximum contribution to society. The problem is—how much of a specialist? How narrow a path should his mind follow?

As plainly as specialization can develop thought, it may narrow, warp, and impoverish the mind. In our own age, specialization has produced the bookkeeper and the machine tender; it has produced the pure technician, the academician, the hordes of "cultural illiterates and expert ignoramuses." Not only can specialization develop individuality—it can deny millions the opportunity of doing truly creative work. It can deny the elemental satisfaction of saying, "I made this." Even the wealth of opportunities it affords is a wealth of square holes for round pegs. In today's civilization there are many more possibilities of going wrong, or—just as bad—of restless doubts that one has made the best possible choice. This is an especially perplexing problem to the technical man—a paradox in which he finds himself. When he specializes sufficiently to compete in his field, he faces the danger of winding up in an intellectual rut.

The sooner a person realizes the import of this inescapable conflict the easier he will be able to cope with the situation. Education has the responsibility of lessening the impact of this paradox on the human spirit. We possess innumerable educational agencies for guiding choice of occupation — or perhaps for intensifying the confusion by multiplying the possible choices. We are only beginning to educate for the all important problem—that of coordinating and humanizing our specialized knowledge, of bringing our experts together and teaching them to speak a common civilized language. For a future still more abundant than the past we must merge technology and the humanities so that each man will be able to enjoy alike his own spiritual and material achievements.



Only a few short years ago

the helicopter was thought to be a "stunt" machine – amazing and amusing, and not particularly important. Events in Korea changed that idea – fast! This fledgling among aircraft performed "impossible" military assignments, spectacularly successful missions of mercy. Helicopters came into their own.

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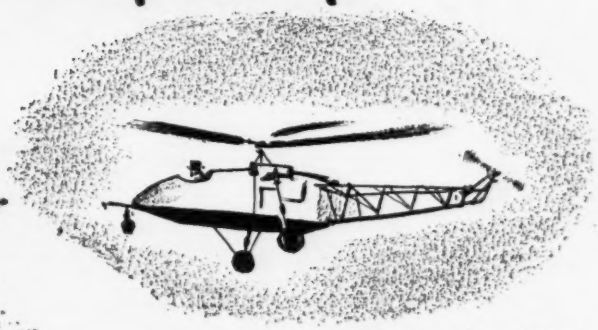
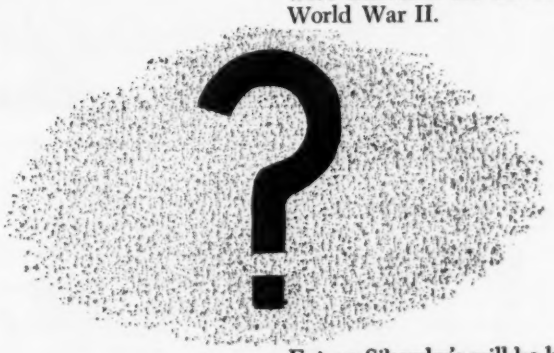


In 1939, the VS-300 with Igor Sikorsky at the controls made the first practical helicopter flight in the United States. Hundreds of later Sikorsky's were delivered for service in World War II.



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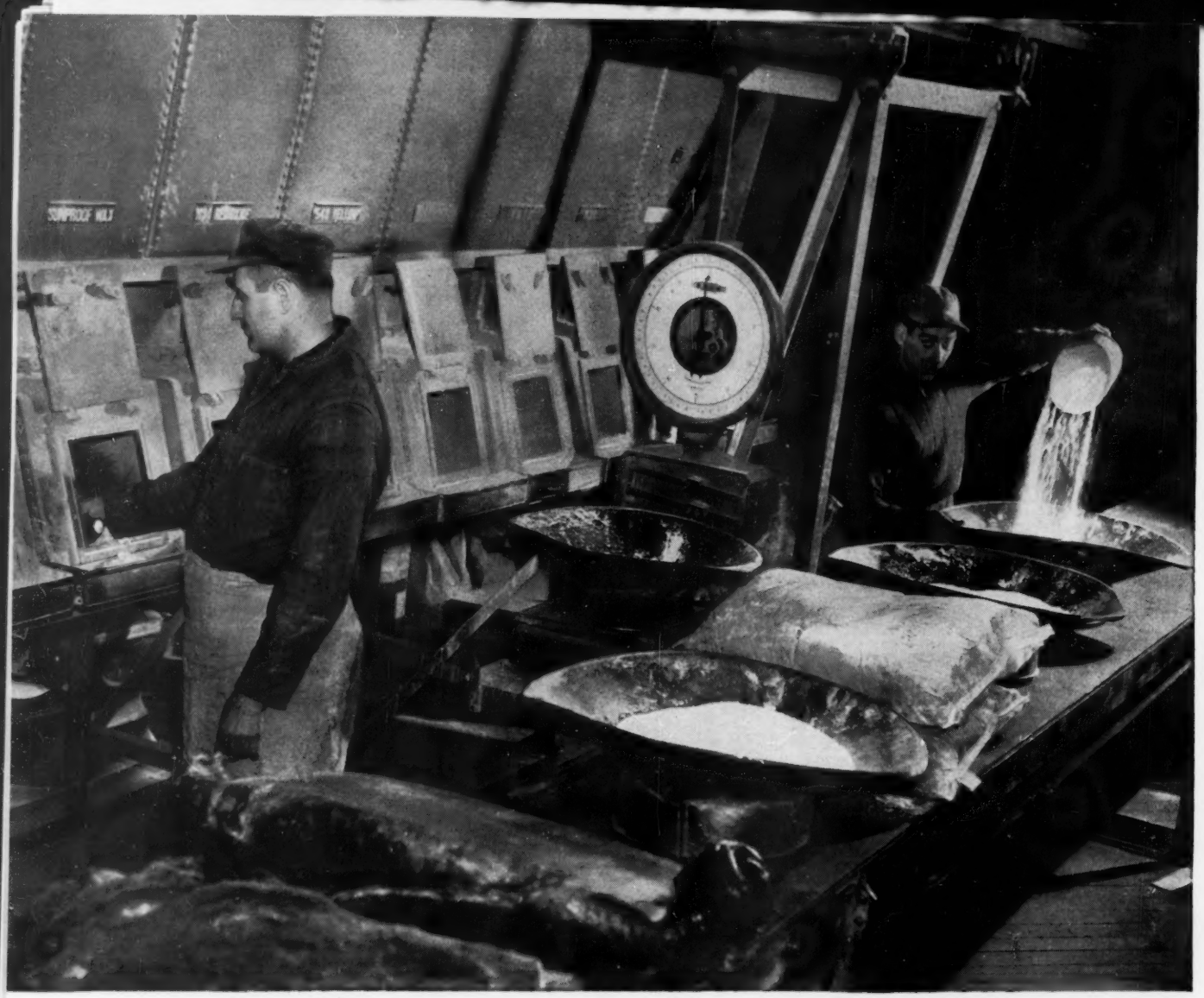

Preparation of Rubber Insulation and Jacket Compounds

MATERIALS AND THEIR PREPARATION. The materials used in the preparation of rubber insulation and jacket compounds may consist of natural or synthetic rubber along with mineral rubber and reclaimed rubber and the necessary compounding ingredients consisting of anti-oxidants, fillers, pigments, plasticizers and vulcanizing agents. The rubber or rubber-like materials are given a preliminary mastication or break-down on rubber mills or internal mixers to facilitate subsequent compounding operations. They are stored in a suitable form until required for compounding.

The required compounding ingredients, except the vulcanizing agents, used in insulating compounds, are carefully weighed into a suitable container. The plasticized rubber or rubber-like materials are weighed last. The vulcanizing agents are weighed in a separate container.

COMPOUND MIXING. Rubber insulation and jacket compounds may be mixed on rubber mills or in internal mixers.

The rubber mill consists of two driven rolls about 28 inches in diameter and from 60 to 84 inches in length. The axes of the rolls are held in a single horizontal plane by the mill frame above a suitable pan. Adjustments are provided to control the spacing between the rolls. Each roll is equipped—for water circulation—for cooling. The rolls rotate in opposite directions in such a manner that the surfaces approach each other at the top. The surface speed of the back roll is about 1.2 times that of the front roll. This difference in surface speed assists greatly in break-down of the rubber and incorporation of the compounding materials.

The rubber-like materials, and mineral rubber, when used, are placed between the rolls first and masticated until so plasticized that they form a continuous sheet on the front roll. The solid ingredients, except the vulcanizing agents for insulating compounds, are then placed on the mill and incorporated in the rubbers. Any solids which drop between the rolls are retained in the mill pan and then returned to the mill.

After the solid materials have been incorporated, the batch is thoroughly blended by cutting the rubber sheet about half way

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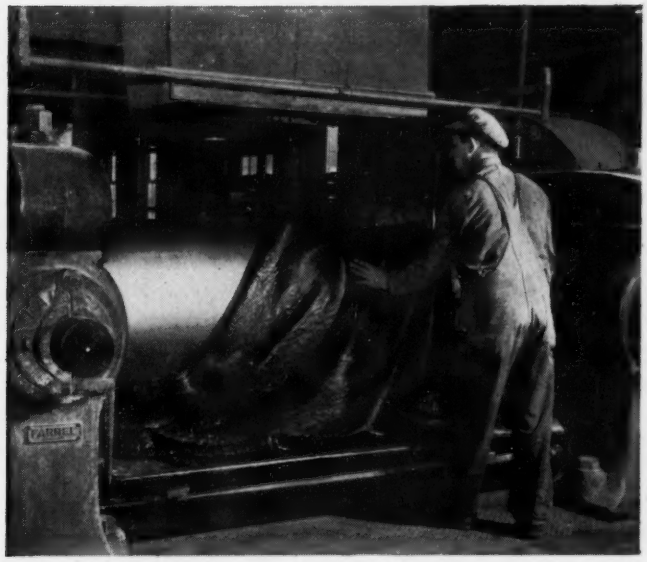
across the roll from alternate ends and folding it back over the uncut portion. This blending may require about fifteen minutes and the entire mixing cycle approximately a half hour. After blending, the compound is removed from the mill in rolls suitable for feeding to the strainer.

The internal mixing unit consists of a mixer located above a rubber mill. The mixer consists of essentially two rotors with spiraled blades rotating in opposite directions at different speeds in a closed chamber. The direction of the spiral of the blades changes at the middle of the rolls. An air-controlled ram forces the materials into the mixing chamber. The mixed batch is discharged from the bottom through a hydraulically operated gate.

The effectiveness of the internal mixer as compared with the mill for breaking down and compounding rubber is evident from a consideration of its method of operation. In addition to the difference in the rate of rotation of the rotors, the interrupted spiral of the blades produces a continuous and uniform movement of the compound

Compound mixing



from the middle to the ends of the rotors. The walls of the chamber are stationary and hence the difference in rate of movement of material adjacent to the rotors and the walls is great. These conditions insure that every part of the batch being mixed will come in contact with every other part in a relatively short time. Mixing requires about fifteen minutes. After mixing, the compound is discharged to the mill below from which it is removed in a form suitable for feeding to the strainer.

STRAINING. The strainer consists essentially of a mechanically driven screw located in a cylindrical cast iron housing. The housing is provided with an opening for feeding the screw and supports the head of the strainer. The head at the outlet end of the screw provides a suitable support for a thirty-six mesh screen through which the rubber insulating compounds are forced by the screw. The strainer operates on the same general principle as the ordinary household food chopper.

The mixed compound is fed into the strainer and forced through the screen. Large particles of foreign or undispersed materials are retained on the screen. The strained rubber compound is returned to a mixing mill or internal mixer where the vulcanizing agents are added. The complete insulating compound is then removed from the mill in sheets for immediate application to wire or for storage.

Jacket compounds are prepared in the same general way as insulating compounds except that the vulcanizing agents are incorporated along with the other solid fillers in mill mixing or on the sheeting mill of the internal mixing unit. Jacket compounds are not strained.

LATEX COMPOUNDING. Compounding rubber in the form of latex involves the handling of rubber in the form of a liquid and, therefore, requires lighter and less costly equipment than that just described for the compounding of plastic rubber. In addition to the actual preparation of the compound, it involves, for latex insulation, the purification of the rubber in latex form.

Latex rubber is purified by diluting a known quantity of latex to approximately 33 per cent solids and heating to a temperature of 150°F. in a steel tank provided with a stirrer. The required amount of creaming agent, dissolved in water, is then added and the mixture stirred. The stirring is discontinued and the warm latex allowed to stand for about 48 hours. The rubber, being lighter than water, rises to the top in much the same way that cream separates from milk. The bottom layer, the serum containing the major portion of the impurities, is discarded leaving the purified rubber in the form of a cream in the tank. This process is repeated until rubber of the desired purity is obtained.

For use in latex compounds, ordinary rubber compounding ingredients are ground more finely, thoroughly protected, and wet with water. This is accomplished in a ball mill. A ball mill consists of a porcelain lined steel drum, provided with a suitable opening and supported with its axis horizontal in such a manner that it can be rotated. The cylinder is about half-filled with flint pebbles.

Definite amounts of the various compounding ingredients, together with the required amounts of protective agents and water, are then placed in the ball mill and suitably ground. Sulfur, being the most difficult material to grind, wet and protect, is milled for about three weeks. All the other ingredients require about one week.

The required amounts of these properly protected and wet ingredients are then carefully weighed and added, along with the stabilizers and water, to a known amount of purified rubber, in the form of latex. The mixture is stirred for about two hours to insure thorough mixing. It is then transferred through a 100 mesh strainer to a storage tank until applied to wire.

Latex compounding

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Walter M. Bacon

"The objects of this Society are to promote the welfare of the College of Engineering at Cornell University, its graduates, and former students and to establish closer relationship between the college and the alumni."

It is of great importance to you as an individual and to all of us as a group that as engineers our professional status not only be maintained at its present level but be greatly improved. Our professional standing today is much higher than it was some years ago but we have not as yet received complete recognition as professional people. We must not only jealously guard and maintain this standing but as individuals we must work to improve it. The opportunity to make this improvement is particularly good at the present time due to the ever increasing importance of the engineer in the life of the country and the world today. What can be done to make engineering equal in standing as a profession to medicine and law? The engineer himself must behave as a professional person. It is his duty to give his client or the management of the company for which he works the benefit of all his background and knowledge and his very best advice under all circumstances. Ethically, the engineer has the responsibility to protect his client or his employer and their interests since they as non-professionals are almost completely dependent upon him. He must take no intentional unfair advantage of his employer or client as the true professional does not trade dishonesty upon the ignorance of others.

Is it possible to meet these ethical standards and at the same time belong to a union of engineers? It does not appear that the two are compatible. A number of engineers unions are in existence at the present time. They are not always called unions but in the long run amount to the same thing as they are organized groups purporting to represent the engineers in negotiating and bargaining with their management in regard to salaries, working conditions, benefits, and other matters. This, although it may not have been the original intent, results in setting up two opposing camps, one of workers and the other of management. It tends to define and at the same time limit the responsibilities of both parties. It causes a leveling process among all grades of engineers and in the long run establishes mediocrity as a goal. While every attempt may be made to keep collective bargaining with management on a high level with a dignified relationship it is almost inevitable that the typical tactics, practices and characteristics of trade unions eventually will be adopted. The average or better than average engineer in such an organization tends to become apathetic in time and eventually finds himself represented by a group of malcontents who are active but do not represent his true feelings and ideas. Under these circumstances it is practically impossible for the engineer to act as a true professional.

—Walter M. Bacon

ALUMNI ENGINEERS

Charles F. Chapman, M.E. '04, has published a new edition of his book, "Piloting, Seamanship and Small Boat Handling." He published a relatively small first edition of this book thirty years ago; however, with each edition the book has grown until it now totals 524 pages. Chapman is editor of Motor "Boating" magazine and lives in Plandome.

Carl D. Hart, M.E. '06, is giving a course in industrial engineering at the college of engineering, University of North Carolina at Raleigh. He and Mrs. Hart plan to return to their home in San Diego, Cal. early in 1955.

George O. Kuhlke, M.E. '14, native of Brooklyn, N. Y., and a leading authority on factory operations and expansion in the field of electronics and precision instruments has left Arma Corp. and established a new business as a management and business consultant in Westbury, N. Y. He will specialize in industrial development and expansion and counseling on finance, Government contracts, personal relations, factory operations and corporate management procedure.

Ronald G. Watt, M.E. '23, lives at 54 Niuiki Circle, Honolulu, T. H., where he is a mechanical engineer and a consulting sugar manufacturer. He is married, has two grown children, and one granddaughter.

Dionisio Suarez, Jr., C.E. '23, is chief engineer of the National Development Commission, Havana, Cuba. He lives in Havana at 8 # 565, Vedado.

Rudolph T. Erickson, C.E. '24, who is secretary-treasurer of the Adams Erickson Co., Inc., Greenwich, Connecticut, is also president of the Building Industry Association of Greenwich, vice chairman of the Building Industry Division of the Chamber of Commerce, and a member of the Cornell Club of New York. In addition to a son, Richard, who is a jet pilot in the U. S. Air Force Reserve, Rudy has two other children: Peter, a graduate of the University of Miami, and Nancy who is attending St. Lawrence College. He lives on Pinecroft Road in Greenwich.

Jacob Yavitch

George A. Bunyan, E.E. '24 has a daughter Ann, who graduated from UCLA Class of 1947. George, a grandfather for the second time, is an engineer with New York Telephone Co., and lives at 9 Watkins Place, New Rochelle.

S. (Sam) Tyson Haldeman, B. Arch. '24 is a partner in the architectural firm of Haldeman & Jacoby, Brockton, Mass., and lives at 9 Hollis Road, South Easton, Mass. He is on the executive board of the American Institute of Architects and for two terms has been a director of the Massachusetts State Association of Architects. He is a member of the Kiwanis Club and the Chamber of Commerce. Sam served four years in World War II and received the Bronze Star as a captain in the Army. He lectures on architectural subjects and for six months he gave a weekly radio broadcast along this line.

Edward A. Proctor, C.E. '25, is president of Proctor & Co., 2220 Dime Building, Detroit 26, Mich. He has been conducting a real estate, mortgage, property management, and insurance business since 1934.

Yasha (Jacob) Yavitch, M.E. '28, M.M.E. '33, is shown left with a four horsepower size gas turbine which he built six years ago when he became interested in developments in this field. He has since organized a company for the manufacture of gas turbines and auxiliary apparatus and is now president and a director of the newly formed Industrial Gas Turbine Co., Glenolden, Pa. Yavitch has been a consulting enginer in the Philadelphia area for more than twenty years.

Melville C. Case, M.E. '32, 822 Morgan Avenue, Drexel Hill, Pa., is engineering division purchasing agent for Rohm & Haas Co., Philadelphia, Pa. He writes that his daughter, **Constance,** entered Cornell last September; her grandfather is **G. Harry Case '02.**

William E. Mullestein, C.E. '32, is general manager of sales and a member of the management committee of Lukens Steel Co., Coatesville, Pa. He has been with the company since 1944 and manager of field sales since 1947. Mullestein, his wife, and two children live in Downington, Pa.

Peter E. Kyle, Met.E. '33, former professor of Metallurgical Engineering, is now with Lesells & As-

Robert Findlay

To be a successful engineer, above all you must know how to cut costs

SIMPLE DESIGN CHANGE TO STEEL CUTS COST FROM $1.15 TO 31¢

BEFORE any product design is accepted, the manufacturer asks, "Can it be built for less money?" Unless your designs pass this test they are likely to be rejected.

Knowing how to use welded steel gives you the advantage in developing any product for lowest cost manufacture. That's because steel is three times stronger than gray iron, two and one half times as rigid, and costs only a third as much per pound. Therefore, where stiffness or rigidity is a factor in a design, less than half the material is necessary.

Here, for example, is how one resourceful engineer put these qualities to work:

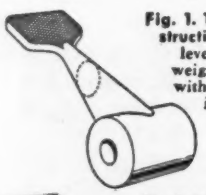


Fig. 1. Traditional Construction. Machine foot-lever, 10 inches long, weighs 6 pounds. Cost with broached keyway is $1.15.

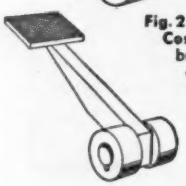


Fig. 2. Simple Steel Design Costs 41% Less. Can be built by the shop with only saw and shears. Weighs 2.7 pounds. Costs 68¢ complete with keyway.

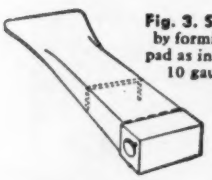


Fig. 3. Saves 53% Cost by forming lever arm and pad as integral piece from 10 gauge metal. Weighs 2.5 pounds. Costs 54¢.

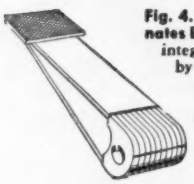


Fig. 4. Saves 73%, Eliminates Broaching. Hub with integral key is produced by stacking stampings in assembly. Arm is 10 gauge, brake formed and welded to hub. Cost is only 31¢. Weighs 2.2 pounds.

Back up your engineering training with latest information on welded steel construction. Bulletins and handbooks are available to engineering students by writing

THE LINCOLN ELECTRIC COMPANY
Cleveland 17, Ohio
THE WORLD'S LARGEST MANUFACTURER OF ARC WELDING EQUIPMENT

sociates, Boston, Mass. He and Mrs. Kyle **(Mary Savage) '40** have a child, the granddaughter of the late Professor **E. Seth Savage, PhD '11**, Animal Husbandry, and Mrs. Savage. The Kyles' address is 24 Meriam Street, Lexington 13, Mass.

Robert C. Findlay, C.E. '42, (above) has been appointed assistant sales manager of the engineered products division of Inland Steel Products Co., Milwaukee, Wis., manufacturers of the Milcor line of steel building products. Findlay, who joined the company after eight years of experience in the design and sales of light gauge metal products, will specialize in the promotion of Milcor Celluflor, a new steel cellular flooring recently introduced.

Robert A. Moore, Chem.E. '43, is a consultant with Process Engineers, Inc. and is vice-president and member of the board of directors of Aquatrols Corp. of America, Inc., directing the sales and merchandising of a new product for gardening and agriculture called Aqua-Gro. Moore's address is Fox Run Road, Box 75, Sewell, N. J.

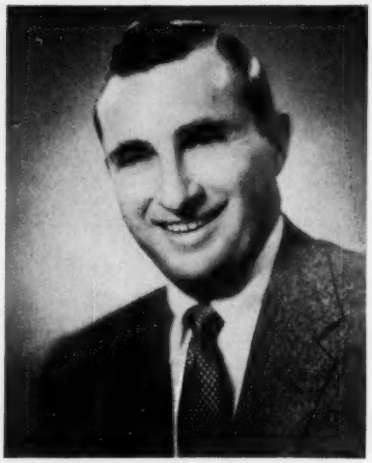
Charles C. Jamison M.E. '45 is a supervising engineer, AGT Division, Westinghouse Electric Corp. He and Mrs. Jamison **(Mary L. Charles) '46** are the parents of Dorothy Anne 5, Thomas Charles 3, and Martha Mary, seven months. They live at 741 Brooke Circle, Morton, Pa. Jamison received the MSinMe from University of Pennsylvania in June, 1953.

Willis S. Zeigler, M.E. '47, 5820 Beard Avenue South, Minneapolis, Minn., announces the birth of a daughter, Patricia Ann, March 23. Zeigler is in the industrial rubber goods sales department of Goodyear Tire & Rubber Co.

Anthony W. Ferara, M.E. '48, 41-15 Fiftieth Avenue, Long Island City 4, is a mechanical engineer with Abbott, Merkt & Co., New York City. He says that **Peter Louisa '48** is in the same office.

Charles von Wrangell, M.E. '48, B.E.E. '49, is in the engineering department of Sikorsky Aircraft at Wesport, Conn.

Robert Bry, M.E. '48, has been appointed to a managerial position in the General Electric Company's Power Transformer Depart-



Robert Bry

ment at Pittsfield, Mass. A native of Deal, N. J., Bry served four years in the U. S. Army Signal Corps prior to his graduation. He graduated as an engineer in feeder voltage regulators, joined the sales section in 1950, and become a traveling specialist for both power transformers and regulators in 1952. Bry is married and lives at 232 Allengate Ave., Pittsfield.

Richard C. Callagan, C.E. '49, is working as a construction engineer with Peter W. Kero, Inc., Lindhurst, N. J. His address is Apartment 1-C, 1055 South Elmora Avenue, Elizabeth, N. J.

Stanley R. Gilbert, Chem.E. '48, 33 Blue Ridge Road, Cranston, R. I., announces the birth of a second child, Gail Beth, January 14, 1954. Gilbert is assistant to the plant manager of the decorative lighting division, Royal Electric Co., Manville, R. I.

Raymond E. Tuttle, Chem.E. '48, Mrs. Tuttle **(Margaret Wilharm),** and their daughter, Susie, now live at 1113 South Success Avenue, Lakeland, Fla. Tuttle is a process engineer with International Minerals & Chemicals Corp.

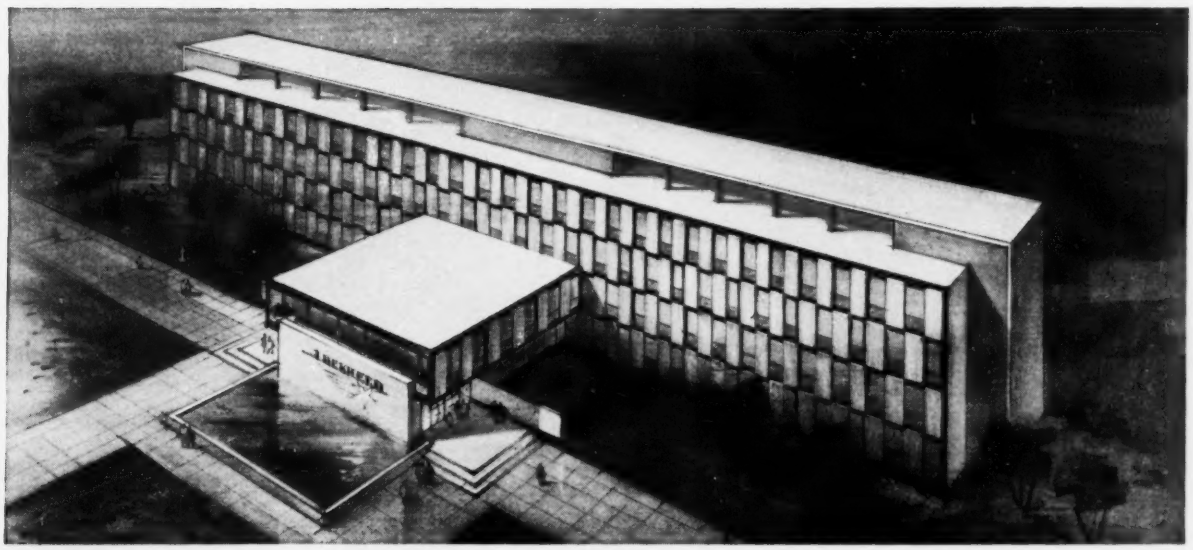
Sahap Yalcin, C.E. '49, is a research engineer in the materials division of the Department of National Highways, attached to the Ministry of Public Works, Ankara, Turkey. He says that he would like to meet any Cornellians passing through. His address in Ankara is Arastirma Fen Heyeti, Karayollari.

NEW MISSILE SYSTEMS RESEARCH LABORATORY

The technology of guided missiles poses increasingly complex problems in virtually every field of science.

To provide physicists and engineers with the most modern facilities for meeting those problems, Lockheed Missile Systems Division has begun construction on a laboratory for advanced research—first step in a $10,000,000 research laboratory program.

Scheduled for occupation in early fall of 1955, it will augment existing Missile Systems Division facilities.



Individuals able to make significant contributions to the technology of guided missiles are invited to contact their placement officer or write us.

Lockheed MISSILE SYSTEMS DIVISION

research and engineering staff

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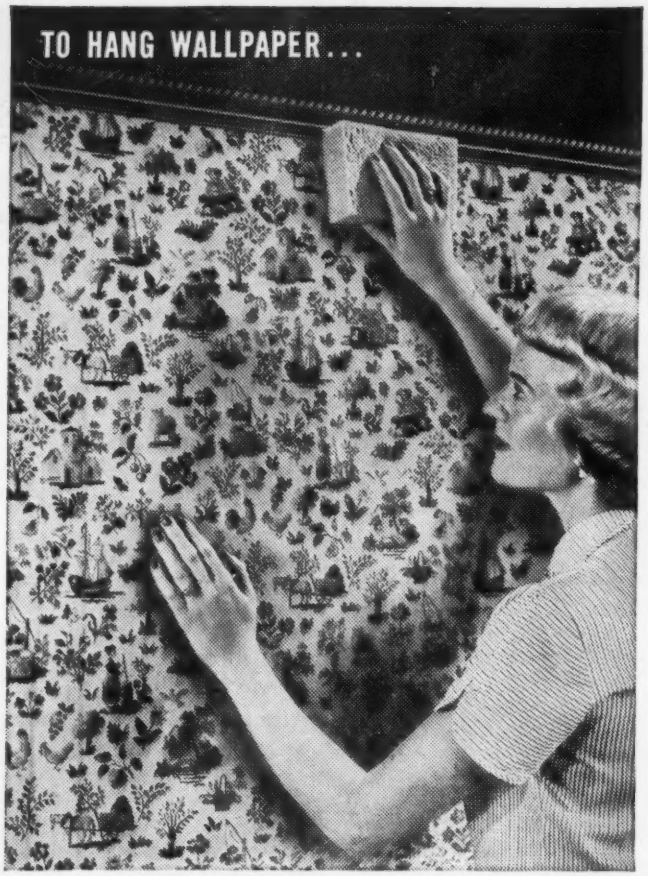
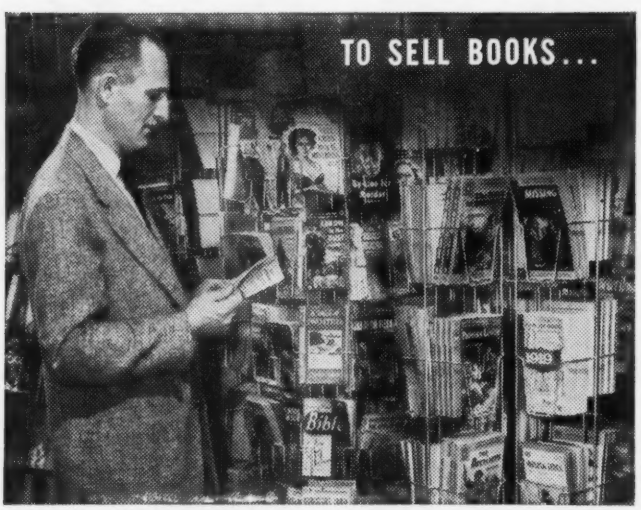


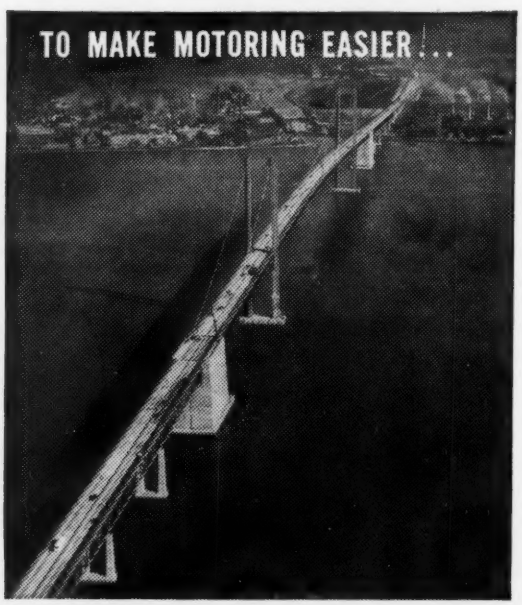
PRE-PASTED WALLPAPER, such as that manufactured by The Birge Company, uses Hercules® CMC to provide a non-staining type paste with adequate slip, permitting ample time for aligning patterns. And to retain its strength when wet, pre-pasted wallpaper relies on Kymene® resin.

HOW HERCULES HELPS...

Most businesses are helped today by Hercules' business . . . the production of synthetic resins, cellulose products, chemical cotton, terpene chemicals, rosin and rosin derivatives, chlorinated products, and many other chemical processing materials—as well as explosives. Through close cooperative research with its customers, Hercules has helped improve the processing or performance of many products.



200 MILLION COPIES of pocket-sized, paperbound books are sold in the nation every year. Hercules resins go into the overprint varnishes that brighten up their covers and encourage impulse sales. Other Hercules chemical materials are used to improve the quality of the paper and printing ink.



BETTER DRIVING is in store for vacationists on highways and bridges protected during winter against ice or snow with Vinsol®, a Hercules-pioneered air-entraining agent in the cement. Also, Parlon®-based paints find wide use for road and crosswalk markings, and other traffic safety devices.

HERCULES

HERCULES POWDER COMPANY
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Wilmington 99, Delaware

G54-8

PITTSBURGH PLATE HAS MANY IRONS IN THE FIRE

... maybe you should have a grip on one of them!

Although Pittsburgh Plate Glass Company is the best known name in glass, it is also one of the nation's leading producers of paints and brushes, of alkalies and related chemicals, of plastics and fiber glass.

These multi-industry operations offer the college graduate many and varied types of careers in manufacturing, research, marketing, sales and administration.

PPG's record is one of continual growth throughout its more than 70 year history. Its operations are nationwide and in many foreign countries. Progressive policies assure unlimited opportunities for alert men who are looking ahead to more than "just a job."

PPG is seeking good men with college training. If you think you'd like to try your "grip" on one of the many PPG "irons," you're invited to write today for more information. Just address: Pittsburgh Plate Glass Company, General Personnel Director, One Gateway Center, Pittsburgh 22, Pennsylvania.

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PITTSBURGH PLATE GLASS COMPANY

319 PLANTS, MERCHANDISING BRANCHES, AND SALES OFFICES LOCATED IN 250 CITIES

Brain Teasers

Being equipped with four more quickies for this month, perhaps we had better settle old accounts first. The first problem last month was concerned with putting a wire around the earth. Since

$C=\pi D$, then, differentiating,

$dC=\pi dD$, and if dC is 10 feet, dD will be 3.18 feet.

The second problem can be untangled by casting out nines, thus:

$3x2=X+3$, so X must be 3

By writing the proper algebraic expressions for our freshman's evening in town, it will become apparent that he wrote a check for $12.57 but was given $57.12, in our third story from real life.

The last one, concerning the flick hounds, is a dirty trick. 80 minutes are the same as one hour and twenty minutes, thus, no explanation is necessary.

Now on to this month's problems.

1) Imagine yourself as an industrial engineer in a jig-saw puzzle assembly plant. The assembly operation has bogged down, and the management would like to know the minimum number of "moves" necessary to assemble an n-piece puzzle, as well as the procedure for obtaining this result.

   Consider the assembly of two pieces as a "move," regardless of whether the pieces so used consist of single pieces or blocks previously assembled.

2) Now transform yourself into a jailer. You are guarding a square block of sixteen cells, each cell opening into all of its neighboring cells. Starting at one corner of the block, can you go to the diagonally opposite corner while entering each cell exactly once?

3) An aside for the benefit of those with a liberal arts education: Can you think of a word that will become shorter if you add a syllable to it?

4) Let's finish up with a game of cards. Shuffle an ordinary deck and turn them face up in pairs. If both cards are black, you get them, but if they are red, I get them. In the event that one is black and the other red, they are discarded and belong to neither of us.

   You will be charged one dollar for the privilege of playing the game, but when the deck is depleted I will pay you three dollars for every card more than I which you have. If you have less than I, you are not charged.

   What is the probability that you will come out of this game financially ahead?

Answers next month. Better get a subscription.

Oil

(Continued from page 11)

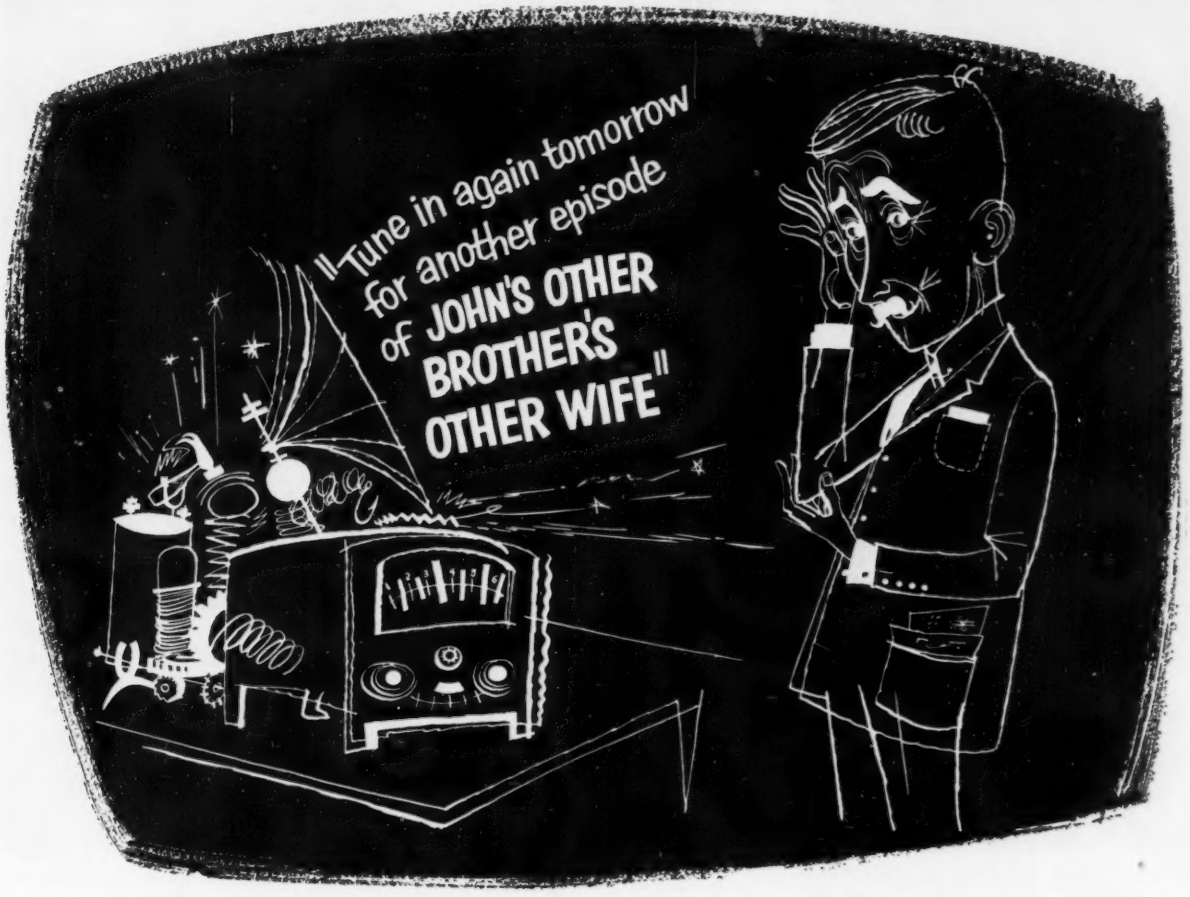
average eight inches in diameter and seldom exceed two hundred feet in depth. A charge in the neighborhood of twenty pounds of dynamite is lowered into each hole by its leads, and the holes are then filled either with dirt or, if the hole is to be used again, with water. The leads of all the shots in a pattern are then connected in series and are ready for use.

While the drilling is under way, the spread of detectors is arranged. Although a variety of spreads are in use, here again to minimize undesirable effects, the detectors are usually extended about a quarter of a mile along the line in each direction from the shot point. They are placed about a hundred feet apart. When planted, the detectors are connected to the recording truck, which is the core of the field operation. Here a bank of recording instruments is mounted inside a totally enclosed mobile room. The most common type of detectors, known as geophones, consist of a movable coil mounted inside a fixed magnet. These instruments have a velocity response and are connected to a row of d'Arsonval galvanometers which record the variations in generated voltage on a strip of film moving past the exposure point at about one foot per second. An amplification system with a variable gain control and a filter is utilized. Since the reflection times are the quantities desired, a time scale must be placed on the film tape. This is achieved by a shutter or a rotating disc which creates marks .01 second apart on the record. The shutter or disc is very accurately controlled by an electrically actuated tuning fork.

Fig. 5. As a "shot" is taken two hundred feet below the ground, the column of water covering it is thrown into the air.

To the string of charges already planted is added a device for indicating the exact instant of explosion. The entire series is connected to a voltage source under the

(Continued on page 38)

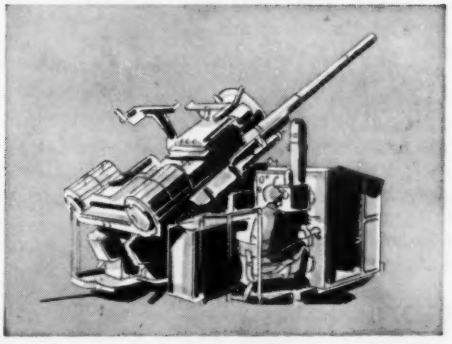


WHAT HATH MARCONI WROUGHT?

Of course, it was years before Mr. Marconi's wireless developed into radio as we know it. Then such wonders as the give-away program, the comedy show and the soap opera blossomed full-blown.

True wonders, too, have sprung from Mr. Marconi's "new departure" of 1897. And New Departure ball bearings have played a vital role . . . in electronic brains for business . . . in automation for industry . . . in radar for defense. In fact, New Departure was a pioneer in developing methods that could turn out ball bearings of ultra-high precision in the mass quantities needed for today's electronic marvels.

Such leadership is one of many reasons why engineers look to New Departure for the *finest* in ball bearings!



The amazing Skysweeper — which sights, tracks and shoots down air targets with fantastic accuracy — depends on New Departure instrument ball bearings for its internal accuracy.

NEW DEPARTURE
BALL BEARINGS

NOTHING ROLLS LIKE A BALL

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONN.

ENGINEERS NEEDED
ON NEW GRUMMAN
SUPERSONIC
TIGER

Grumman, one of the most stable aircraft companies in the industry, needs engineers to work on the supersonic Tiger and new Cougar II. With Grumman, your home will be Long Island, the playground of New York. If you are an experienced aircraft engineer, or a recent engineering graduate, send your resume to Engineering Personnel Dept. Interviews at Employment Office.

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Oil

(Continued from page 36)

control of the shooter. This man is in telephone contact with the observer running the equipment inside the recording truck. When the geophones have been connected and checked, and the charges are ready, with no other disturbances such as automobiles or airplanes within range, the observer starts running the tape and instructs the shooter to fire. The entire recording process does not last more than four seconds, after which the film is quickly developed in the darkened truck. This process is repeated along the entire length of the line.

When the record is taken to the office, it must be interpreted and computed. Reflected events are picked and timed, and computations are made on the basis of the average velocity in the area, the spread used, the elevation of the shot point and detectors, and an allowance for the weathered beds. Steeply dipping strata add further complications. However, from the several horizons computed for each shot, a profile of the line is plotted, and from it, the elevation of a "phantom" horizon is indicated on a surface map of the area. When the lines have all been shot, the depths are contoured. An example of such a completed map is shown in figure 4. Anticlines and domes show up quite clearly, while reefs will appear as small anticlines. Stratigraphic traps and faults, however, are much more difficult to detect, and wide experience in interpretation is helpful in their detection, since they give unusual reflection-dip segment patterns.

Thus, by a long and difficult process the much sought-after subsurface contour map appears. It is not an end in itself, but must be further analyzed by other departments to evaluate the advisability of drilling on the apparently high area. The exploration party, in presenting as accurate a picture of sub-surface conditions as possible, has fulfilled its obligation to help keep pace with the consumption of our most valuable raw material.

Corrosion

(Continued from page 8)

ing its best to puncture a hole or scale away the armored plating. This is the phenomenon called "corrosion" which cathodic protection attempts to combat.

Cathodic Protection

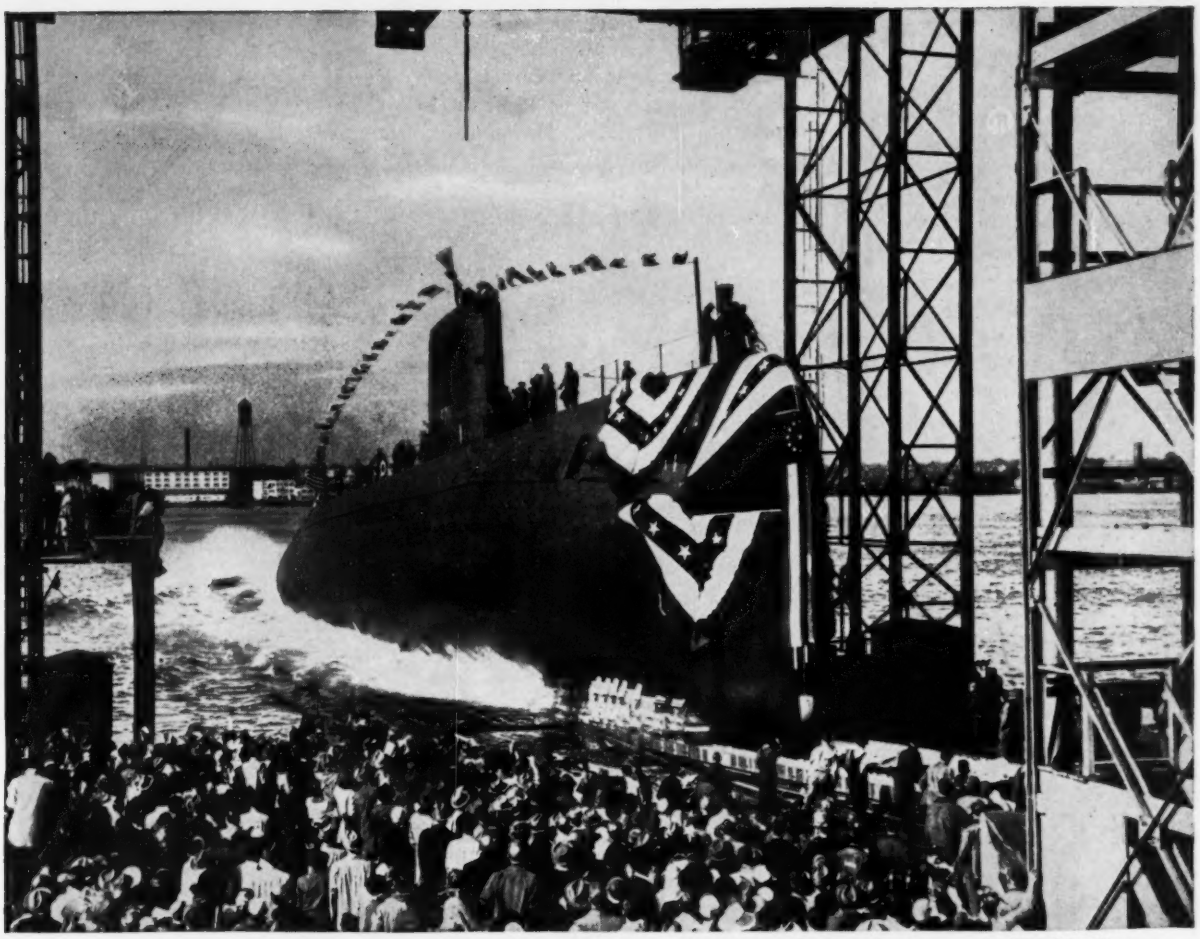
The application of cathodic protection means just this: opposing the flow of corrosive currents by causing all areas of the metallic structure to become cathodic. This is achieved by impressing a relatively small negative potential on the metal.

It has been shown that when a negative potential of from .85 to .95 volts, with respect to a reference electrode, has been impressed on the hull of a ship, the local anodic and cathodic areas are effectively neutralized and corrosion and pittings are mitigated. This external potential, applied to oppose and neutralize the galvanic corrosive current, may be maintained in several ways. One of them is by using several magnesium bars suspended in the sea water around the ship and electrically connected to the hull. Since magnesium is less noble in the electromotive series than steel, it becomes anodic and develops a galvanic-cell reaction with the ship. In so doing, it impresses a sufficiently large negative voltage on the hull to prevent local cell reactions from forming. The magnesium is consumed in this galvanic reaction. For this reason anodes of this type are often termed "sacrificial."

The second method, and the most important so far as the Atlantic Reserve Fleet is concerned today, is an impressed current system. This uses a graphite anode, but because this material is relatively inert, a transformer and rectifier are attached electrically between the carbon anodes and the steel hull in order to impress the necessary positive voltage on the anode. This transformer and rectifier system is driven by a shore power supply.

Thus we have the problem and we have a method for counteracting it. We have the materials, manpower, shore power and means for putting this method to work. And that

(Continued on page 40)



SLIDING DOWN THE WAYS at Groton, Conn., goes the USS Nautilus, newest and fastest member of our underseas fleet. During welding, Worthington heavy-duty turning rolls rotated the hull sections.

How the world's first atomic sub was welded

Welding the hull of the USS Nautilus, world's first atomic submarine, presented a tough problem.

Submerged-arc automatic welding seemed to be ideal for the job. Question was—could you rotate the hull sections of the Nautilus to take advantage of this fast, high-quality welding method?

Worthington's answer to General Dynamics Corporation's Electric Boat Division, builder of the Nautilus, was the largest turning roll ever built.

The result? Welding of the Nautilus hull was accomplished in record-breaking time — and cost less than originally estimated. Unchanged, the Worthington roll set-up is also being used in the construction of the nation's second atomic sub, the USS Sea Wolf.

Turning rolls for submarines aren't all that Worthington makes. The long list of Worthington-designed, Worthington-built equipment includes air conditioning units, construction machinery, compressors, Diesel engines, steam power equipment and, of course, pumps of all kinds. For the complete story of how you can fit into the Worthington picture, write F. F. Thompson, Manager, Personnel and Training, Worthington Corporation, Harrison, New Jersey. You may be glad you did.

4.25 B

See the Worthington representative when he visits your campus

See the Worthington Corporation exhibit in New York City. A lively, informative display of product developments for industry, business and the home. Park Avenue and 40th Street.

WORTHINGTON

When you're thinking of a good job—think high—think Worthington

AIR CONDITIONING AND REFRIGERATION · COMPRESSORS · CONSTRUCTION EQUIPMENT · ENGINES · DEAERATORS · INDUSTRIAL MIXERS
LIQUID METERS · MECHANICAL POWER TRANSMISSION · PUMPS · STEAM CONDENSERS · STEAM-JET EJECTORS · STEAM TURBINES · WELDING POSITIONERS

Corrosion

Continued from page 38)

is just what has been done during the past several years in the Atlantic Reserve Fleet. With many dry-docking inspections and numerous changes in the original installations, the following results have been shown:

a. Underwater corrosion *can* be controlled on Reserve Fleet ships.

b. The protection is ineffective near the surface of the water.

c. The current and potentials have little effect on fouling of the underwater hull.

d. There are still unmet problems. These include "shadow effects," deterioration of the carbon anodes, methods of varying the impressed current voltage to correspond to changes in salinity (and thus the resistance of the sea water), etc. These must all be solved before this method of corrosion control can be made 100% effective.

The net gain, even in its still imperfect state, is considerable. For the price of a couple of 20 amp rectifiers, a comparatively small transformer, a few graphite anodes and miscellanous wire — the cost of which amounts to an average outlay of $500 per ship—we can control the underwater corrosion by the use of a system which closely corresponds to the basic Reserve Fleet policy of the most preservation for the least manpower, materials, and funds.

A sailor stands guard over part of our Moth-ball Fleet.

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Should escaping gases ignite, the Grinnell ProtectoSpray System again would function effectively. The wide, evenly distributed pattern of fine water droplets would permit safe, controlled burning of the gases. Also, the water spray, even without dependence on wind, would provide sustained air movement to hasten the dilution of escaped gas . . . at the same time providing additional inert vapor to speed the dilution process.

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There is a Grinnell Fire Protection System for every fire hazard. For further information, write: Grinnell Company, Inc., 260 West Exchange St., Providence, Rhode Island.

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Atomic Energy

(Continued from page 16)

nuclear power will be only as cheap as the power we buy today from the utility companies. But the great appeal that nuclear power holds forth is that, while the world's conventional fuel resources are exhaustible and are being consumed at an ever-increasing rate, nuclear fuels are virtually inexhaustible. The world's energy sources, let us say, may be measured in a unit "Q", equal to 10^{18} BTU, or 40 billion tons of coal, or 170 billion barrels of oil. The world is currently consuming its energy resources at the rate of 20Q per century, and in the year 2000, this rate will climb to 100Q per century. The world's reserve estimate is 70Q for economically recoverable coal, and 8Q for oil and gas. At the present consumption rate, the world's supply will endure for 400 years, at the rate 55 years hence, for only 80 years. In contrast, nuclear fuels are virtually limitless, and moreover, one pound of a nuclear fuel burned in a reactor will unleash as much energy as 2,600,000 pounds of coal.

The development of nuclear power will free our exhaustible conventional fuels for uses in fields where atomic power will never be economically or scientifically practical, such as the automobile industry. Uses will always be found for conventional fuels; these must be conserved as efficiently as possible.

A nuclear reactor is unlike any heat generating device we know today. It must contain costly and bulky shielding apparatus to protect workers from harmful radiations, and corrosion- and radiation-resistant systems. Few men in the atomic energy field believe a nuclear power plant can ever be built as cheaply as can a conventional one, for shielding and other necessary and costly apparatus will make its cost unusually high compared to that of plants being erected today. A coal-burning plant of, say, 200,000 KW capacity, today costs $180 per KW to construct. A nuclear power plant would cost many times that figure per KW of capacity. It has been estimated

(Continued on page 44)

1927—Covering wing of early Boeing plane, Seattle plant

1955—B-47 Stratojet assembly, Boeing Wichita Division

Boeing offers engineers long-range careers

Throughout its 38-year history, Boeing has consistently pioneered advanced new types of military and commercial aircraft, and new methods of production. This history of leadership has meant continued growth for the company. It means continued opportunities for Boeing engineers to move ahead according to their ability in Research, Design and Production.

Today Boeing is producing the jet age's outstanding bombers, the B-52 and the B-47. Other Boeing projects that mean continued growth and stability include: America's first jet transport (the Boeing 707). Research in nuclear-powered and supersonic flight. And one of the nation's major guided missile programs. These and other new-horizon projects are expanding at such a rate that Boeing now employs more engineers than even at the peak of World War II.

The high inherent interest of these programs, together with the stimulation of expanding opportunities, add to the stability of careers at Boeing. One measure of stability is given in this chart.

It shows that 46% of Boeing engineers have been with the company for five or more years; 25% have been here 10 or more years, and 6% for 15 or more years. Another measure is the increasing proportion of engineers to total employees. Fifteen years ago the figure was one to 16. Today one out of each seven employees is an engineer.

Boeing promotes from within and holds regular merit reviews to assure individual recognition. Engineers are encouraged to take graduate studies while working and are reimbursed for all tuition expenses.

Boeing has openings for virtually all types of engineers—electrical, civil, mechanical, aeronautical and related fields, and for applied physicists and mathematicians with advanced degrees.

For further Boeing career information consult your Placement Office, or write:

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Atomic Energy

(Continued from page 42)

that, in order that atomic power compete with conventional power, one may spend no more than $60,000,000 for a nuclear plant designed to generate the same amount of electricity as a $40,000,000 coal-burning plant. Cost analyses indicate that 80 per cent of the cost of producing electricity is absorbed in initial construction and distribution facilities; only 20 per cent is expended on fuel. Consequently, while the cost of nuclear fuels will be negligible, increased distribution and construction outlay render nuclear power unable to currently compete with conventional power. However, the day will arrive when the former at least will approach competition with the latter.

Submarine Thermal Reactor

Although nuclear power generation is today economically impractical, it is militarily advantageous. Thus, today, the major part of the AEC's reactor program is concentrated on the development of atomic engines to propel military craft. A nuclear power plant to propel the world's first atomic submarine has been perfected and is now in operation; it is called the Submarine Thermal Reactor (STR), and was developed by Westinghouse at the AEC's laboratory in Pittsburgh, For fuel, the STR employs uranium enriched in U-235; the fuel is formed into solid pieces of metal and submerged in a tank of water which serves both as coolant and moderator. Circulating water removes the heat produced by the reactor to a boiler where steam is formed to operate a turbine which propels the submarine as well as a turbo-generator to produce electricity. The atomic submarine is the world's first "permanent" submarine, for it is not forced to surface in order to charge the storage batteries which operate a conventional undersea vessel.

Large Ship Reactor

A natural as far as reactors are concerned is an atomic-powered warship. An atomic-powered aircraft carrier is forthcoming in the near future, and undoubtedly other surface craft will be propelled in the same manner after the initial development.

Aircraft Reactor

The main obstacle preventing the perfection of atomic-powered flight is the lack of a shield light enough to be taken aloft. A test facility at the AEC's Reactor Testing Station in Idaho is now experimenting in the field of nuclear-powered aircraft. Once materials suitable for a shielding to be installed in aircraft have been developed, airplanes will have virtually unlimited range.

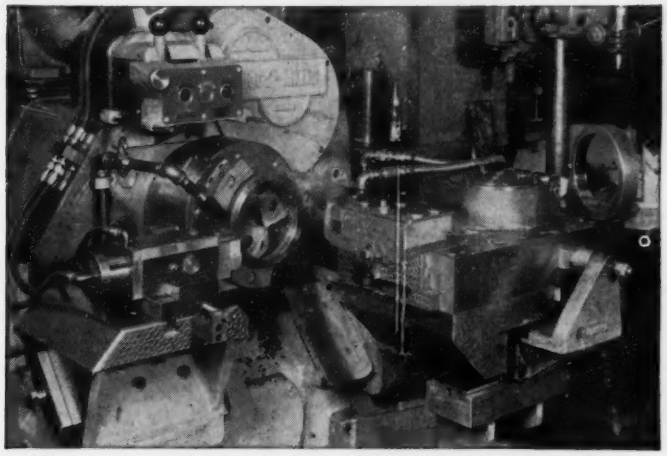
Atomic-powered Locomotive

Studies with an eye to nuclear-powered rail travel have been made by the Union Pacific Railroad, with the following conclusions: a locomotive complete with reactor would cost approximately $1,200,000, twice the price of a conventional freight diesel; moreover, since diesel fuel is likely to rise in price with time, an atomic-powered locomotive is expected to be economically sound in the near future, at a price of uranium of about $20 per gram. The AEC has kept the price of uranium a secret, but $20 per gram is not an unreasonable estimate according to experts. A great problem in the design of such a locomotive is the inevitable crack-up and possible blow-up of the reactor.

Conclusion

Every one is agreed that man will eventually unleash the energy within the atom to put it to work for him for peaceful uses. The only variable is the time element; meanwhile, the world anxiously awaits the day when that near-millenium in science arrives.

Another page for **YOUR BEARING NOTEBOOK**

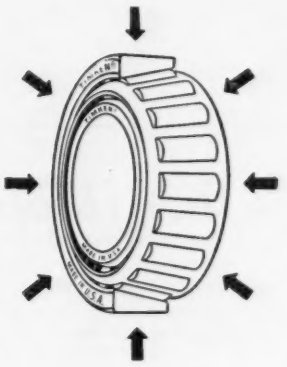


How to machine with high precision at high speeds

This lathe is designed to machine the races of bearings from 4″ to 8″ in diameter. And it must deliver high precision at speeds and feeds as fast as carbide tools can handle. To keep the spindle rigid under heavy combination loads, it's mounted on Timken® tapered roller bearings.

How TIMKEN® bearings maintain spindle rigidity

Because Timken bearings take radial and thrust loads in any combination, they hold spindles in rigid alignment, insure precision. And full line contact between the rollers and races of Timken bearings provides extra load-carrying capacity, prevents breakdowns.



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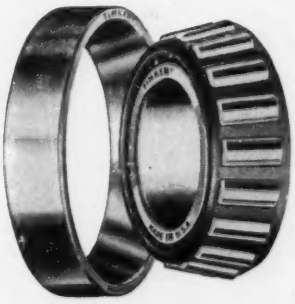

Want to learn more about bearings or job opportunities?

Many of the engineering problems you'll face after graduation will involve bearing applications. For help in learning more about bearings write for the 270-page General Information Manual on Timken bearings. And for information about the excellent job opportunities at the Timken Company, write for a copy of "This Is Timken". The Timken Roller Bearing Company, Canton 6, Ohio.

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College News

Mechanical Engineering School has Revised Curriculum

Although the option characteristics of Cornell's mechanical engineering curriculum are on their way out, three classes of Sibley Students still are doing their work under the two options. The class of mechanical enginers which entered Cornell in 1952 was the last offered the choice of two options; the following class now operates under one curriculum designed to incorporate the major elements of options A and B.

Option A

Option A was established for those students desiring specialization in one field of mechanical engineering such as mechanical design, heat power engineering, or refrigeration and air conditioning. Consequently more courses in these fields are required; those included in the Option A schedule not in the Option B curriculum comprise: Engineering 3505, refrigeration and air conditioning, Engineering 3506 and 3507, steam power and combustion engines, and a fourth term of electrical engineering. In addition, eleven elective hours are offered; five must be Arts and Sciences courses.

Option B

Option B was designed to satisfy needs of those students interested in the industrial, manufacturing, and management phases of mechanical engineering. The Department of Industrial and Engineering Administration provides courses in these fields; Option B replaces the Administrative Engineering program formerly offered at Sibley.

Courses required of Option B students not demanded of those in Option A are the following: Industrial Statistics, three methods and production engineering and two heat power courses, standard costs, and industrial marketing. Only six elective hours are offered.

New Curriculum

The recently formulated curriculum first offered to the students intending to graduate in 1958 combines the features of both option A and B, leaving more room for elective house (twenty nine as opposed to eleven and six), and condensing several courses, such as accounting, steam power and combustion enengines, and refrigeration and air conditioning. Of the elective hours set aside, at least eleven must be taken in the liberal arts, at least eight in engineering. Where as most

Wings that *flapped*

were strictly for the birds

KF-BS Bearing

A generation ago, about everyone thought that airplane wings should be rigid to be safe. Not so today. Designers of today's high speed planes have found that safety hinged on wing deflection.

To insure unrestricted control systems on wings that bend, Fafnir developed a standard series of Self-Aligning Torque Tube Type Ball Bearings which provide friction-free movement, reduce cost and weight. By keeping in step with aircraft progress, Fafnir continues to lead in the production of aircraft bearings. The Fafnir Bearing Company, New Britain, Conn.

Available
A motion-sound picture depicting high points in manufacture and use of Fafnir Ball Bearings is available to engineering classes. Write to The Fafnir Bearing Company for details.

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BALL BEARINGS
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put yourself in his place . . .

A year ago he was knee-deep in textbooks, plugging for his B.S. Tonight he's on his way to Vancouver, or Miami, or Portland, Maine. Tomorrow he'll help an Alcoa customer make a faster ship, a stronger shovel, a lighter highway trailer.

In Alcoa laboratories, plants and sales offices from coast-to-coast, ambitious young Sales Development Engineers are helping to make aluminum more useful, in more ways, to more people. We need more men just like them to help us meet ever-growing demands for Alcoa Aluminum . . . Alcoa "know-how".

Maybe you are already thinking about trading your textbooks for a position in production supervision, industrial research or sales engineering. Tell us about it, give us an idea of your background in Chemical, Electrical, Mechanical, Metallurgical or Industrial Engineering.

Good men go places fast with Alcoa, in their daily associations with leaders in the aluminum industry. Right now it may be quicker than you think from a seat in the classroom to your career with Alcoa. Why not find out?

Your Placement Director will be glad to make an appointment for you with our Personnel Representative. Or just send us an application, yourself.

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TECHNIQUES

applied to the design, development and application of

AUTOMATIC RADAR DATA PROCESSING, TRANSMISSION AND CORRELATION IN LARGE GROUND NETWORKS

ENGINEERS & PHYSICISTS

Digital computers similar to the successful Hughes airborne fire control computers are being applied by the Ground Systems Department to the information processing and computing functions of large ground radar weapons control systems.

The application of digital and transistor techniques to the problems of large ground radar networks has created new positions at all levels in the Ground Systems Department. Engineers and physicists with experience in the fields listed, or with exceptional ability, are invited to consider joining us.

fields include

TRANSISTOR CIRCUITS
DIGITAL COMPUTING NETS
MAGNETIC DRUM AND CORE MEMORY
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VERY HIGH POWER MODULATORS AND TRANSMITTERS

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RESEARCH AND DEVELOPMENT LABORATORIES

Culver City, Los Angeles County, California

Relocation of applicant must not cause disruption of an urgent military project.

elective hours were in effect denied ROTC students in either of the options, these men are now able to simultaneously finish their military science courses and acquire some knowledge of the Arts.

CSE to Meet

On February 17, 1955 the third meeting of the Cornell Society of Engineers will be held at the Engineers Club, 32 West 40th Street, New York City.

All Cornellians and their friends are invited to the meeting which will start at approximately eight o'clock. Prior to the meeting there will be a buffet supper about 6:30 P.M., for which there is a charge of $3.50. Attendance at the supper is purely optional. However, if one elects to attend please telephone Bill Leonard at GRamercy 3-5600, Ext. 4336, or write him c/o Con-Edison, Room 1633S, 4 Irving Place, New York 3, New York.

The speaker of the evening will be William Littlewood, M. E., Class of '21. His topic is: "How Do We Fly From Here?" Mr. Littlewood is internationally known as a leading engineer of the Air Transport industry. He is presently Vice-President, Research & Development, American Airlines. He is also president of the Society of Automotive Engineers and past Vice-President of the Institute of Aeronautical Sciences, with many outstanding achievements in the aeronautical field, among which is the Award of the S.A.E. Wright Brothers Medal in 1935. In 1952 he was the Wright Brothers' Lecturer for the I.A.S.

Prof. Kellogg Gives Talk

Prof. Paul Kellogg of Cornell described "Adventures in Wildlife Sound Recording" at an open meeting sponsored by the Ithaca section of the Institute of Electrical Engineering on Friday, January 7.

Dr. Kellogg, professor of ornithology and biological acoustics in Cornell's conservation department, is nationally famous for his recordings of bird songs and other natural sounds. He is a member of the Explorers Club.

Prof. Katz to Give Paper At SAE 50th

An aircraft engine of the future will be described by Prof. Israel Katz of Cornell during a 50th anniversary meeting of the Society of Automotive Engineers.

The paper on "Optimum Flow Dilution in Ducted-Fan Engines" will be presented during the SAE Golden Anniversary Aeronautics meeting to be held in New York City in April.

It will demonstrate a generalized analytical technique which Professor Katz developed for determining the optimum, but critically interrelated, influential factors affecting the design of ducted-fan turbopowerplants.

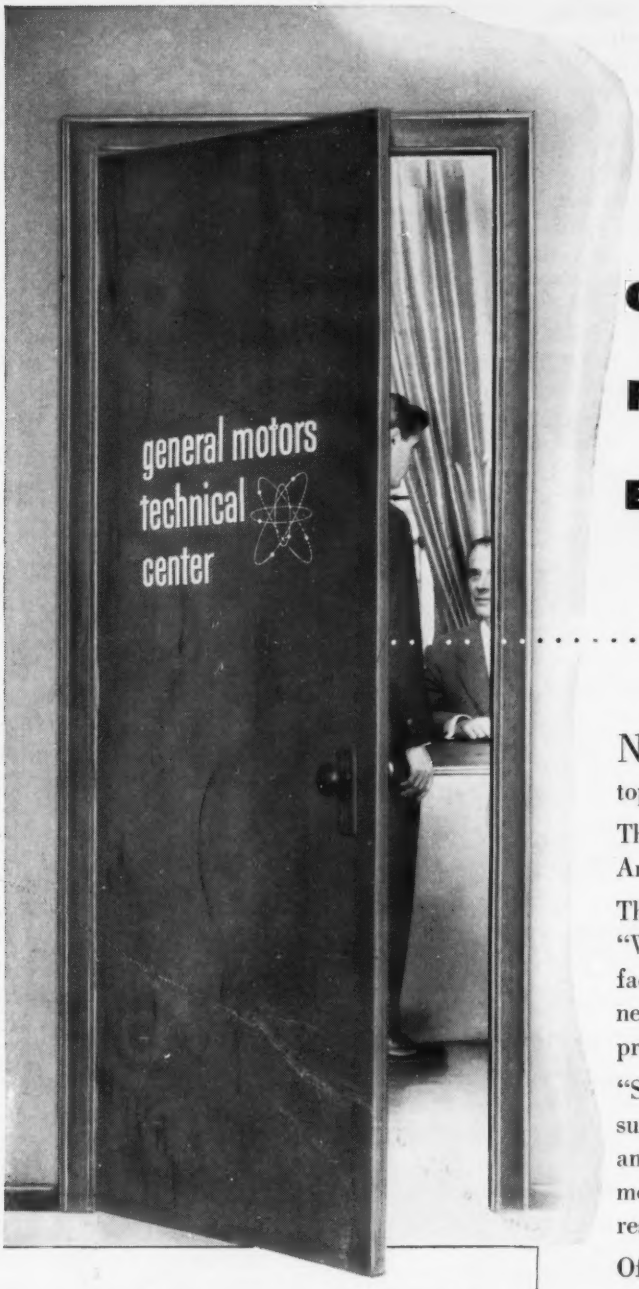
Engine designers generally agree that the ducted-fan engine is potentially one of the most economical and versatile types of aircraft gas turbines and that it is the type destined to propel the majority of future jet transports.

Professor Katz is in the Thermal Engineering Department of the Sibley School of Mechanical Engineering at Cornell. The paper will be part of a session on "Future Powerplants."

CAL Completes New Tunnel

The Cornell Aeronautical Laboratory, Inc. today announced completion of a new wind tunnel that will permit further fundamental and exploratory research in the transonic and supersonic speed ranges—speeds at and beyond that of sound. The new tool, built for the U.S. Air Force, is valued at more than $600,000.

Project Engineer John G. Wilder of the Laboratory's Aerodynamic Research Department said that although aircraft capable of flight in the transonic and supersonic ranges have been built, many basic problems of airflow and design remain unsolved. This is particularly true in the transonic speed range (700 to 900 mph) where mixed subsonic and supersonic flows exist side by side. Mr. Wilder said such problems



OPEN DOORS FOR ENGINEERS

Now more than ever, our nation needs engineers in top policy-making positions.

That's what Alfred P. Sloan, Jr. recently told the American Institute of Consulting Engineers.

The Chairman of the Board of General Motors said, "We need the respect that the engineer has for basic facts. We need his analytical frame of mind. We need his imagination. We need his contact with interpretation and control of the physical forces.

"Such is the type of discipline, as I see it, that is sure to contribute to a maximum degree of order and sense in our complicated economy — and promote the best and most efficient use of our national resources, both human and material."

Of course, these words — so typical of GM's entire outlook — foretell great things for engineers in the country at large. But even more, they explain why career opportunities for good men are so exceptional here at General Motors.

We invite you to write for "The College Graduate and General Motors," a booklet that should encourage you to see the GM College Representative when he visits your campus.

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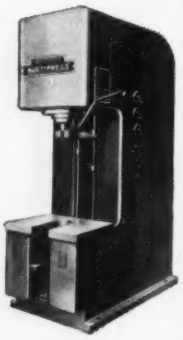

The truck of the car—minus wheels and axle—is mounted on a Denison hydraulic Multipress. The press ram raises and lowers the truck, simulating up-and-down riding characteristics. In 30 days, the springs and snubbers get the equivalent of 10 years' wear on the road.

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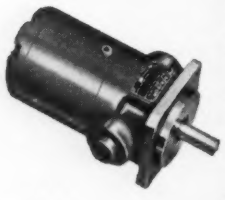

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can best be handled by thorough experimentation.

The new tunnel is now going through a shakedown period before actual testing is begun. Technically, it is known as a continuous flow, vertical return, variable density transonic-supersonic wind tunnel. These features permit the engineer to collect data as closely approaching free-flight conditions as is presently possible. Dimensions of the test section are one-square foot.

One of the first problems facing engineers using the new tunnel will be the further development of transonic testing techniques. The purpose of any wind tunnel is to simulate as completely as possible the conditions of free flight. At transonic speeds great problems arise because of severe wave reflections from the wall and "choking" in the tunnel. This prevents the collection of accurate and useful data. The Laboratory has solved some of the basic problems in collecting this transonic data by development of a "perforate" wall type section that ventilates the section, eliminates choking, and cancels wave reflections. The new tunnel will be used for further refinement and development of the "perforated" wall technique as well as for research on transonic flow.

ASEA Officers Named

Five Cornell faculty members have been elected to offices in the American Society for Engineering Education.

Two from the School of Civil Engineering were named to offices in the society's graduate studies division. Director N. A. Christensen was named chairman and Prof. Andre L. Jorissen, head of hydraulics and hydraulic engineering, was named secretary.

Prof. Dwight Gunder, head of the Dept. of Engineering Mechanics and Materials, was named to the executive committee of the society's mechanics division.

Two men were appointed to the society's general council. Prof. A. J. McNair, head of surveying in the School of Civil Engineering will represent the civil engineering division and Prof. O. C. French, head of the Department of Agricultural Engineering, will represent his field.

Two Cornell alumni were prominent in the meetings. The principal speaker was Major Lenox Lohr, president of the Museum of Science and Industry in Chicago, who received an ME degree at Cornell in 1916.

The society's George Westinghouse Award for engineering teaching was given to Thomas J. Higgins of the University of Wisconsin, who received EE and MA degrees at Cornell in 1932 and 1937.

White Museum Offers Bridge Exhibit

An exhibition of 38 photographic panels depicting bridges of the United States has opened at the Andrew Dickson White Museum of Art at Cornell.

Entitled "Bridges Are Beautiful," the show is sponsored by the American Institute of Steel Construction and circulated by the American Federation of Arts. It is exhibited here through the cooperation of the museum and the Department of Structural Engineering.

The bridges were chosen for their beauty of design and are classified according to their structural principles. They include the Golden Gate Bridge at San Francisco, a spidery pipeline bridge in Louisiana, overpasses for pedestrians, and a movable bridge in Jacksonville, Fla.

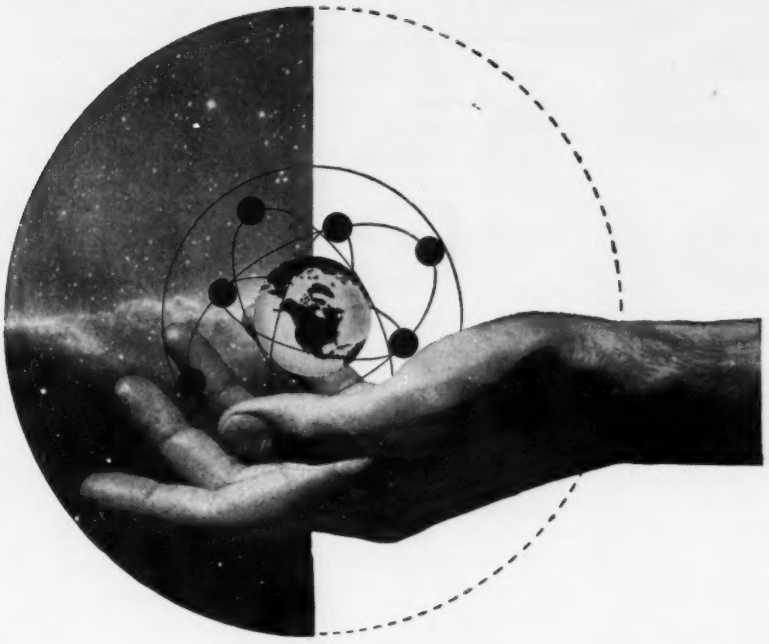
Prof. Wilson to Return From France

Professor Robert R. Wilson, director of Cornell's Newman Laboratory of Nuclear Studies, is at the University of Paris as an consultant in the construction of an electron accelerator of the synchrotron type, similar to the one at Cornell.

Professor Wilson and his family flew abroad, and expect to return to return to Ithaca this month.

Professor Wilson will lecture at the Sorbonne as well as the University of Paris, in addition to working on the accelerator with physicists from the University of Paris and the French government.

Prof. Dale R. Corson is acting director during his absence.



brand new world

As a major step in its pace-setting program of advance planning, The Glenn L. Martin Company has expanded its operations into the field of nuclear power.

This means that a top team of scientists, physicists and engineers is being integrated under the Martin method to carry on a planned, long-range program in this tremendous new science.

There are exceptional opportunities for creative engineers.

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Technibriefs

General Electric announces the development of two new silicone rubber gums for the manufacture of silicone rubber compounds.

The development polymers were designed to be combined with a new du Pont filler to obtain maximum reinforcement. The new compounds have a tensile strength from 200 to 300 pounds per square inch and also have 50 per cent higher elongation.

One of the gums has a normal shrinkage and flexibility at minus 65°F while the other has lower shrinkage and retains flexibility below minus 100°F. The latter is especially adapted to the needs of the aircraft industry.

Although the new gums are commercially available, they are still in the developmental stage and are being subjected to improvements to permit more efficient combination with the du Pont silica filler.

Computer Works in Refinery

Research scientists of Socony-Vacuum Oil Company, Inc. will soon put a high-speed electronic digital computer to work figuring out how to set the valves and fire the stills in an oil refeinery to achieve most efficient operating conditions.

Scientists, engineers, and businessmen attending the Eastern Joint Computer Conference at Philadelphia will visit the Paulsboro laboratories December 9 to watch Mobilac, as the brain is called, in action. The conference is a joint meeting of the American Institute of Electrical Engineers, the Institute of Radio Engineers, and the Association for Computing Machinery.

The program for determining most efficient refinery operating conditions, one of the first undertaken in the oil industry, will be carried on in cooperation with the staff of Socony-Vacuum's refinery at Paulsboro.

To conduct the program, the laboratory scientists have constructed a mathematical model of the Paulsboro refinery, using numbers and formulae to represent processing units. This model consists essentially of a group of about 100 equations which express mathematically the behavior of catalytic cracking, reforming, and other processing and blending units at the refinery. These equations are punched on cards, which are read by Mobilac and stored in its memory. Next, additional punch-cards containing data on crude oil characteristics, available charge stocks, motor gasoline specifications, produce commitments, and other operating conditions and requirements are fed into the computer. Mobilac will then add, subtract, multiply, and divide these factors in the proper way and come up with answers in as little as 15 minutes.

To do Mobilac's computations with hand calculators would require simultaneous operations of 250 to 300 of them. Mobilac can solve problems in algebra, calculus, or logic. It can add or subtract 500 ten-digit numbers a second, multiply 120 a second, and divide 85 a second. It has a good memory—good enough to remember more than 4,000 ten-digit numbers. It can make choices or decisions based on the results of its calculations.

Powerful Drink For Jets

Water and alcohol "highballs" served to the six General Electric J47 jet engines powering the Air Force's Boeing B-47 bombers have provided the swift Stratojets with extra power for takeoff.

Although not the conventional-type highball, a mixture of water and alcohol is injected into the combustion chambers of each of the six jet engines as a spray. This process increases both the mass flow through the engines and the velocity of the jet gases thus providing the greater thrust.

Water injection combined with a new external rocket arrangement has provided the 600-mile-per-hour bomber with an increase in available takeoff power. The additional power enables the swept-wing Boeing bomber to operate from shorter fields or to lift maximum loads from existing runways.

General Electric enginers explained that the increased mass flow of the gases through the engine in the water injection system is accomplished by adding the mass of water vapor to the normal mass of air and burned fuel in the J47 engines.

This added mass increases the thrust. The alcohol, which burns like the regular fuel fed to the engines, is added to the water in sufficient quantity to completely vaporize the water. An alcohol mixture is used because it can be easily injected and does not require complicated engine control adjustments.

Tinted Glass— Safe for Night Driving

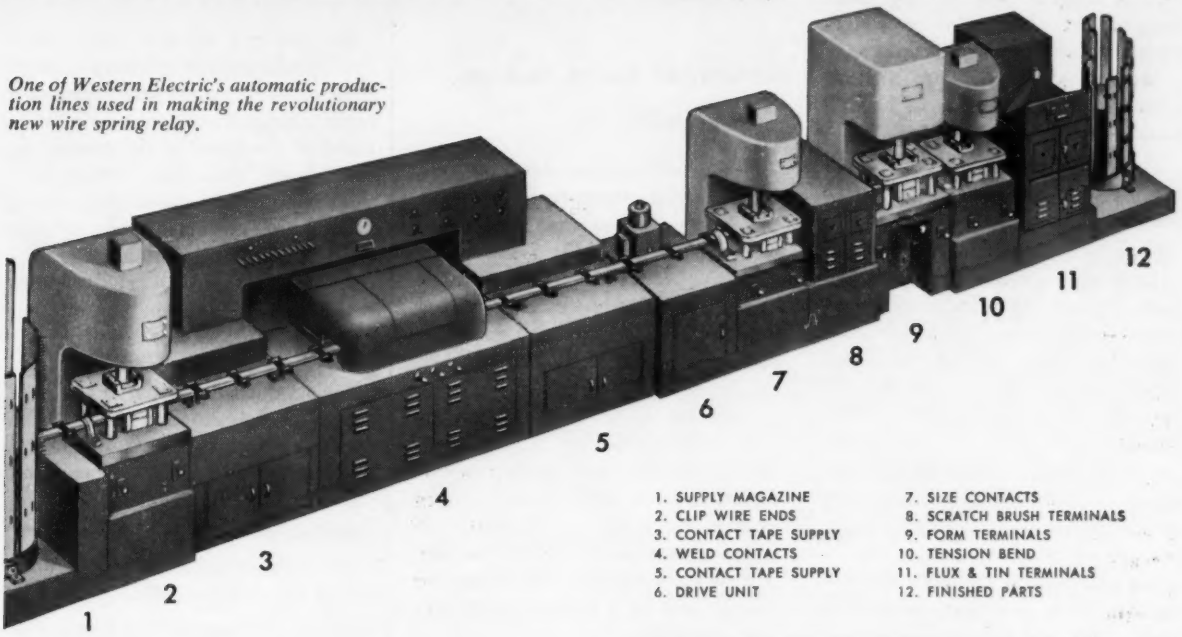
Actual road tests show little difference in a motorist's night seeing distance through tinted and standard windshields, according to a paper presented today before the Highway Research Board. The difference in seeing distance between conventional safety glass and heat absorbing or tinted windshields was shown to average only 3 per cent or 9 feet in a distance of 300 feet, insignificant in night driving. Overall results matched exactly a similar series of night-time seeing road tests in 1952 at Orlando, Fla., although some conditions of the earlier tests were less severe than in this new series.

Tinted glass absorbs more than half the radiant infrared energy from the sun's rays. It reduces heat from sunshine through car windshields and windows to increase comfort. It also reduces daytime glare and is an advantage even in winter when the ground is white with snow. This infrared absorption is accomplished by a small reduction in light transmitted through the glass to about 73 per cent as compared with 87 percent for conventional windshields. This is above the American Standard Safety Code requirements for windshields. How-

AUTOMATION at work

How a revolutionary new design was translated into a production reality

One of Western Electric's automatic production lines used in making the revolutionary new wire spring relay.



1. SUPPLY MAGAZINE
2. CLIP WIRE ENDS
3. CONTACT TAPE SUPPLY
4. WELD CONTACTS
5. CONTACT TAPE SUPPLY
6. DRIVE UNIT
7. SIZE CONTACTS
8. SCRATCH BRUSH TERMINALS
9. FORM TERMINALS
10. TENSION BEND
11. FLUX & TIN TERMINALS
12. FINISHED PARTS

So great was the departure in design of the new Bell System wire spring relay as compared with conventional relays that it posed a major undertaking for development engineers at Western Electric, the manufacturing and supply unit of the Bell System. Indeed, it was an undertaking that called for new machines and new methods because none was available to do the job.

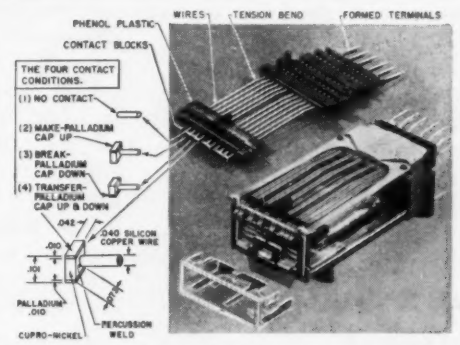
Longer life, higher operating speed, lower power consumption, and lower manufacturing cost were some of the advantages promised by the new relay design. Engineers reasoned that a lower manufacturing cost could be achieved through greater precision in manufacture (which would cut adjustments) and through extensive use of automatic processes.

One of the products of this reasoning is pictured at the top of this page. This battery of equipment, developed by Western Electric product engineers, constitutes one phase of wire spring relay manufacture, which automatically performs several separate operations. Its function begins after one of the fundamental elements of the new relay has been fabricated. This element, known as a "comb," consists of a multiplicity of small diameter wires in parallel array imbedded for part of their length in molded phenol plastic.

These molded elements, of which there are two types used in the new relay, are delivered to this line of machine units in magazines. By fully automatic means they are removed from the magazine, carried by a reciprocating conveyor through each of the several processes and, when completed, placed into another magazine to await further assembly.

Between the first and final magazine the automatic battery of equipment does the following operations: clips wire ends, attaches palladium contacts to wire ends by means of percussion welding, sizes contacts, forms terminal, tension bends wires, fluxes and tins terminals.

Most remarkable of all is the fact that this is a *precision* operation throughout. For example, the small block contacts, which are percussion welded to the tips of wires of one type of "comb," must be located on the same plane across the twelve contact positions to within a tolerance of ± .002".



Single Wire Comb with Percussion Welded Contacts, Wire Spring Relay Designed by Bell Telephone Laboratories

One type of "comb" element is shown at top while a completed wire spring relay is below. The small blocks of metal on the ends of the wires are cut from a composite tape during the automatic multiple percussion welding operation. "Contact conditions" are determined by the code of relay being manufactured and may vary greatly.

Western Electric

MANUFACTURING AND SUPPLY UNIT OF THE BELL SYSTEM

Manufacturing plants in Chicago, Ill.; Kearny, N. J.; Baltimore, Md.; Indianapolis, Ind.; Allentown and Laureldale, Pa.; Burlington, Greensboro and Winston-Salem, N. C.; Buffalo, N. Y.; Haverhill and Lawrence, Mass.; Lincoln, Neb.; St. Paul and Duluth, Minn. Distributing Centers in 29 cities and Installation headquarters in 15 cities. Company headquarters, 195 Broadway, New York City.

daytime, drivers see equally well through tinted windshields because the eye adapts itself to brightness changes. At night, the paper reported, there is a slight difference in seeing distance because the eye is less adaptable to loss of brightness.

Two outstanding facts pointed out by the extensive test data were:

1. Only a 3 per cent change in night driving speed—as little as 1½ miles less at 50 miles per hour—completely compensates for this slight difference in "threshold seeing distance" between heat absorbing and ordinary safety glass windshields.

2. This small amount of compensation is negligible compared with speed adjustments drivers make because of road conditions, headlights and general night visibility—whether it is a bright, moonlight night, dark and rainy or foggy.

Heat absorbing glass, first introduced in 1950 following extensive tests, did not become available in all automobiles until 1952. More than five million cars have been purchased with this optional equipment glass which costs the car buyer $25 to $45 extra.

Pocket Radio Transmitter, Solar Powered

A solar-powered experimental radio transmitter, the size of a package of cigarettes, has been built by a General Electric development engineer, Edward Keonjian.

The transmitter is self-contained. It uses transistors instead of electron tubes, and selenium solar energy converters instead of batteries. When light rays strike the selenium, sufficient elctrical energy is delivered to the transistors to operate the transmitter.

The transmitter currently has a short range, about 100 feet, which could be improved by increasing the number of selenium solar energy converters or using silicon or germanium instead of selenium.

Keonjian believes that developments in light sensitive elements over the next decade may make practical small personal radio transmitters and receivers powered by solar energy.

Reversible Pump-turbine To Be Built

The world's largest electric motor and reversible pump-turbine will be the heart of a pump-storage project at Hiwassee Dam in southwestern North Carolina on the Tennessee Valley Authority's power network and is scheduled for completion late in 1955. Construction of the equipment is currently being started by Allis-Chalmers.

In this installation a single hydraulic machine will operate in one direction as a turbine and in the reverse direction as a pump. A direct-connected electrical machine will serve as a motor for pump operation and as a generator for surbine operation.

When in service, water from the Hiwassee reservoir, driving the unit as a turbine-generator, will add needed energy to the TVA system in peak demand periods. During off-peak periods, when surplus power is available from other plants, the unit will operate as a motor-driven pump to lift water back into the reservoir. It will act, in other words, as a huge storage battery for storing energy.

The project has many unsual aspects. The reversible pump-turbine will utilize the largest Francis-type runner ever built. As a turbine it will have a maximine rating of 120,000 horsepower. When motor driven, the unit will have a pumping capacity of 3.3 billion gallons of water per day, or nearly three times as much as New York City requires.

The pump has more than three times the capacity of each of those serving the Grand Coulee irrigation project, which are presently the world's largest.

The electrical motor-generator is equally imposing. As a motor it will be the world's largest, rated 102,000 horsepower, 106 revolutions per minute. It is approximately 50 per cent larger than the motors driving the Grand Coulee pumps. As a generator it is rated 70,000 kva, 13,800 volts.

Projects

(Continued from page 19)

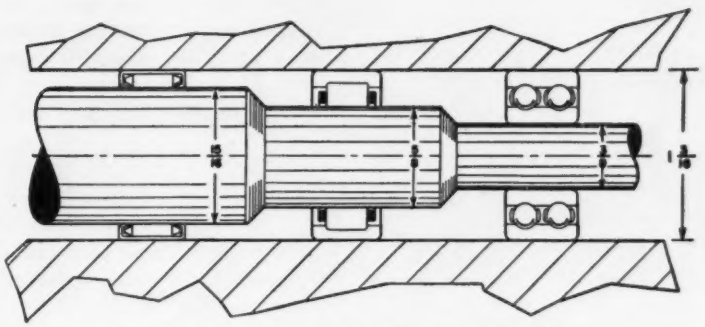
At the end of the first term's work, most project advisors request their students to prepare a progress report, formally written as a summary of the state of the project at that time. This is done both to help the advisor to determine that term's grade, and to clarify the proper course of effort to conclude the project. Oral progress reports may sometimes be used in conjunction with or instead of the written report. A final report, resembling a "thesis", must be prepared and presented to the project advisor at the end of term ten. It contains an explanation of the nature, scope, and objectives of the problem explored, together with a presentation of results, conclusions, and suggestions about continuation of work on the same topic. Some departments give a grade for the final report while others do not.

An example of an interesting project is being carried on by a student in the School of Electrical Engineering. This involves the design and construction of a special type of magnetic amplifier, in which certain hysteresis properties of a coil-core alloy, together with a selenium rectifier, may be made to replace electron tubes or transistors in some low frequency applications, particularily in servomechanism circuits. This student succeeded in developing a magnetic amplifier having an A-C input, an original idea, (although unfortunately he was "scooped" by someone at General Electric very recently working on the same problem.) Much of his equipment was furnished by the Westinghouse Corporation, on contract for a copy of the results when they are obtained.

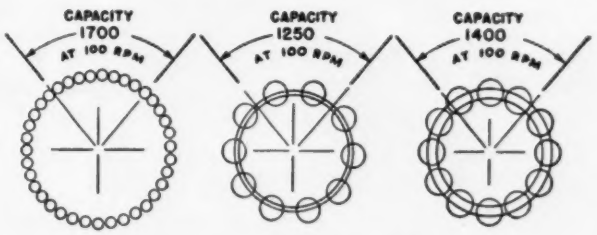
The range of possible topics is immense. The more time a man gives himself to think about his selection, the better are the chances of liking his project well enough to put all of his effort into it.

The Torrington Needle Bearing
is designed for high radial loads

The many lineal inches of contact provided by the larger number of small diameter rollers give the Torrington Needle Bearing an unusually high load rating. In fact, a Needle Bearing has greater radial capacity in relation to its outside diameter than any other type of anti-friction bearing.



1. *Illustrates the fact that for a given housing bore size, a larger and, therefore, stiffer shaft can be used with Needle Bearings than with a roller or ball bearing.*



2. *Shows the greater number of lines of contact in the load zone of a Needle Bearing compared with a ball or roller bearing.*

Precision Manufacture and Unique Design

The exceptional load capacity of the Needle Bearing is the result of proper selection of steels, precision workmanship to close tolerances, and the application of modern anti-friction principles.

The one-piece shell, which serves as the outer raceway and retains the rollers, is accurately drawn from carefully selected strip steel. After forming, it is carburized and hardened. There is no further grinding or other operation that might destroy the wear-resistant raceway surfaces. The full complement of thru-hardened, precision-ground rollers is retained by the turned-in lips of the one-piece shell.

The small cross section of the Needle Bearing allows a large shaft which permits a rigid design with minimum shaft deflection, a factor of utmost importance to good bearing design.

THE TORRINGTON COMPANY
Torrington, Conn. • South Bend 21, Ind.
District Offices and Distributors in Principal Cities of United States and Canada

TORRINGTON NEEDLE BEARINGS

NEEDLE • SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • BALL • NEEDLE ROLLERS

STRESS and STRAIN...

A truck driver, hauling clay for a fill, backed his truck too far over the dump grade. The weight of the load being dumped lifted the front end of the truck several feet off the ground.

"Now, what are you going to do?" an associate asked.

The driver eased out of the cab and said, "I think I'll grease it—I'll never get a better chance."

* * *

Captain (on ferry, yelling into crew's quarters): "Is there a macintosh down there big enough to keep two ladies warm?"

Voice from below: "No, but there's a MacPherson who's willing to try."

* * *

I think that I shall never see
A girl refuse a meal that's free;
A girl with hungry eyes not fixed
Upon a drink that's being mixed;
A girl who doesn't like to wear
A lot of junk to match her hair;
But girls are loved by guys like me
'Cause damn if I will kiss a tree.

* * *

Reader: "Do you make up these jokes yourself?"

Editor: "Yep, out of my head."

Reader: "You must be."

* * *

Skidding is the action
When friction is a fraction
Of the vertical reaction
Which won't result in traction.

"How can I ever show my appreciation?" gushed a woman to Clarence Darrow, after he had solved her legal troubles.

"My dear," replied Darrow, "Ever since the Phoenicians invented money there's been only one answer to that question."

* * *

The tightwad, out of town on his wife's birthday, sent her a check for a million kisses as a gift. The wife, annoyed by his extreme thrift, sent this postcard:

"Dear Jim: Thanks for the perfect birthday check. The milkman cashed it this morning."

* * *

"Your husband looks like a brilliant man—I'll bet he knows everything."

"Don't be silly—he doesn't even suspect a thing."

* * *

Papa Robin returned to the nest and proudly announced that he had just made a deposit on a brand new Buick.

* * *

Sonny: "Pop, what's an optimist?"

Father: "An optimist is a man who thinks his wife has quit smoking cigarettes when he finds cigar butts in the house."

* * *

Coroner: "And what were your husband's last words?"

Widow: "He said: 'I don't see how they can make any profit on this stuff at a dollar a quart'."

* * *

Salesman: "Sir, I have here something that's guaranteed to make you the life of the party, allow you to win friends and influence people, help you forge ahead in the business world, and in general make life a more pleasant and invigorating experience."

Engineer: "I'll take a fifth."

A Pacific coast bootleggerette was nabbed by the police, who found six pint flasks in her bloomers. How's that for a kick in the pants?

* * *

When you argue with a fool—be sure that he isn't similarly engaged.

* * *

Traveler: "Quick give me a round trip ticket!"

Clerk: "Where to?"

Traveler: "Back here, you fool!"

* * *

Several weeks ago, coming home from work on a crowded bus, I stood next to a woman and her small son. I asked her if she wasn't afraid the little boy would be crushed.

"Not at all," she answered. "He bites."

* * *

"Sugar Pie, did that kiss ah just gave you make you long for another?"

"Sho did, Boy, but he's out of town."

* * *

A good story is the one of the lawyer who journeyed to California to try an important case, promising to wire his partner the moment a decision was announced. At long last the wire came and it read, "Justice has triumphed." the partner in New York wired back, "Appeal at once."

* * *

She: "Does your husband still find you entertaining?"

Her: "Not if I can help it!"

* * *

"Beg your pardon, but aren't you an engineering student?"

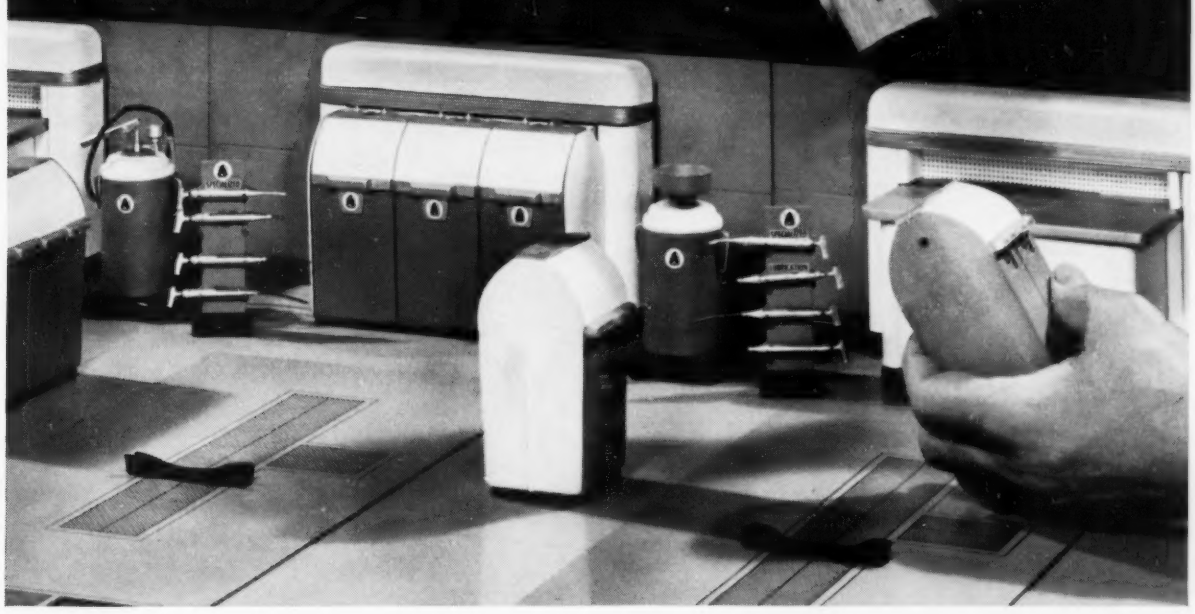
"No, it's just that I couldn't find my suspenders this morning, my razor blades were gone, and a bus ran over my hat."

PHOTOGRAPHY AT WORK—No. 8 in a Kodak Series

Kodak
TRADE-MARK

Photography shows prospects

how their new service stations are going to look and operate



Alemite sets up scale models of their service station equipment on the customer's own floor plan—photographs them—and portrays the new custom-built station ready for action

SALESMEN don't just pull lube racks, grease pumps and other service station equipment out of a sample case. They're far too big—far too bulky. Besides, final location and arrangement count heavily in how well they are going to work out.

The Alemite Division of Stewart-Warner solves the problem with photography. Prospects see new service station equipment virtually right in their own premises.

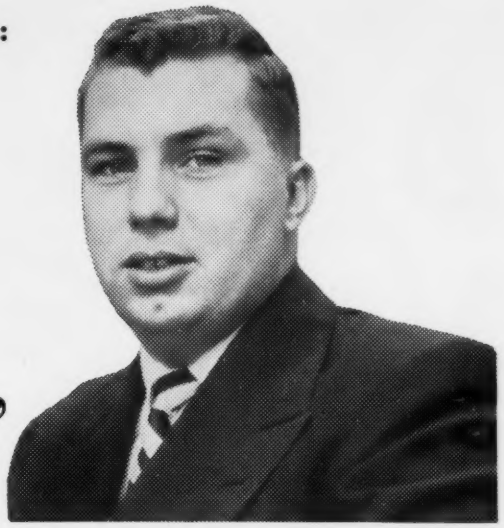
It works this way. The salesman sends in a rough sketch of the space available, with windows and columns marked. Experts fit exact replicas of racks, lifts, and other equipment to the plan, then put the camera to work. The customer pictures his new station—modern, efficient, handsome—and the sale is well on its way. It's an idea for any company with bulky products to sell. Photography is a great salesman for any business, large or small. And it's very much more. It works in all kinds of ways to save time, cut costs, reduce error and improve production.

Graduates in the physical sciences and in engineering find photography an increasingly valuable tool in their new occupations. Its expanding use has also created many challenging opportunities at Kodak, especially in the development of large-scale chemical processes and the design of complex precision mechanical-electronic equipment. Whether you are a recent graduate or a qualified returning service man, if you are interested in these opportunities, write to Business & Technical Personnel Dept., Eastman Kodak Company, Rochester 4, N.Y.

Eastman Kodak Company, Rochester 4, N.Y.

JOHN B. NOLTE, Purdue University '54, asks:

"What is G.E.'s Manufacturing Training Program?"



The Manufacturing Training Program at General Electric is a program of basic training for manufacturing leadership, including planned rotational work assignments and related classroom study for outstanding young men who are interested in a career in manufacturing. It was organized to meet the increased demand for effective manufacturing leadership and technical "know how," in line with the expansion and development of the Company's operations by developing trained men to fill future key positions in the organization.

Who is eligible for this program?

In general, the Program is open to college graduates with degrees in engineering and science, and a limited number of business administration and liberal arts graduates. We are looking for outstanding young men with sound educational backgrounds, well-balanced personalities, demonstrated thinking abilities, and having the potential to develop toward top level responsibility in key assignments.

How long is the program?

The normal length of the Program is three years. Assignments are normally 6 months in duration and provide experience opportunities in diversified manufacturing operations. Geographical moves occur at annual intervals.

What type of work assignments are made?

Work assignments are provided in all phases of manufacturing and related functions so that each man will acquire knowledge of manufacturing engineering, including manufacturing methods and techniques, shop operation, production control, personnel administration, labor relations, engineering activities, sales and manufacturing co-ordination, and general business administration.

In addition to job assignments, related study courses cover such subjects as Company organization, manufacturing operations, labor and personnel relations, business administration, law and relationships between manufacturing and other functions of the business. Progress on the job and in classroom work is carefully observed and reviewed periodically with each man to assist him in his career.

What happens after training is completed?

After completing the training program, graduates are placed in operating departments and divisions throughout the Company in positions where leadership and initiative are needed. All placements are made in relation to the aptitudes, abilities, and interests of the graduates.

At General Electric, manufacturing operations involve the administration and supervision of activities of more than 100,000 men and women in more than 100 plants, who are involved in the making of some 200,000 different products.

The wide scope of these activities, the great variety of products, and the diversity of manufacturing activities offer limitless opportunities and exciting challenges to college graduates today.

Manufacturing training is a foundation for leadership—and an opportunity to build a satisfying, rewarding career in one of America's most important industries.

If you are a graduate engineer, or a graduate with definite technical inclinations that include an interest in the career possibilities in manufacturing, see your college placement director for the date of the next visit of the General Electric representative on your campus. Meanwhile, for further information on opportunities with General Electric write to Manufacturing Training Services Section, Bldg. 36, General Electric Company, Schenectady 5, New York.

You can put your confidence in—

GENERAL ELECTRIC